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Pharmaceutical Nanotechnology

Aims & Scope

Pharmaceutical Nanotechnology publishes original manuscripts, i.e. primary technical papers, rapid technical notes, reviews and commentaries that provide insights into the synthesis, characterisation and pharmaceutical (or diagnostic) application of materials at the nanoscale. The nanoscale is defined as a size range of below $1\ \mu\text{m}$. Scientific findings related to micro and macro systems with functionality residing within features defined at the nanoscale are also within the scope of the journal. Manuscripts detailing the synthesis, exhaustive characterisation, biological evaluation, clinical testing and/ or toxicological assessment of nanomaterials are of particular interest to the journal's readership. Articles should be self contained, centred around a well founded hypothesis and should aim to showcase the pharmaceutical/ diagnostic implications of the nanotechnology approach. Manuscripts should aim, wherever possible, to demonstrate the *in vivo* impact of any nanotechnological intervention. As reducing a material to the nanoscale is capable of fundamentally altering the material's properties, the journal's readership is particularly interested in new characterisation techniques and the advanced properties that originate from this size reduction. Both bottom up and top down approaches to the realisation of nanomaterials lie within the scope of the journal.

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Editor-in-Chief



Zongjin Li

Department of Pathophysiology
Nankai University School of Medicine
Tianjin
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[Biography](#)



Biography of Zongjin Li



Dr. Zongjin Li is a Professor at the Department of Pathophysiology and a Director of the Laboratory of Molecular Imaging and Stem Cell Therapy at Nankai University School of Medicine, Tianjin, China. He received his PhD degree from Peking Union Medical College and completed his postdoctoral training in the Molecular Imaging Program (MIPS) at Stanford University, USA. He has published more than 120 peer-reviewed papers on molecular imaging and stem cell therapy.

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Co-Editors

Jay B. Ramapuram

Department of Drug Discovery and Development



Harrison School of Pharmacy
Auburn, AL
(USA)

[Biography](#)



Biography of Jay B. Ramapuram



Dr. Ramapuram Jayachandra Babu is currently a Professor and Graduate Program Officer at the Department of Drug Discovery and Development, Harrison School of Pharmacy, Auburn University. He received his Bachelor's degree in Pharmacy from the University of Madras and Masters and PhD degrees in Pharmaceutics from Indian Institute of Technology, Varanasi, India. His research interests include formulation development of nanoparticle based formulations for topical and oral delivery, solubility improvement of insoluble drugs, percutaneous penetration enhancement techniques, and transdermal drug delivery systems. He has authored and co-authored over 90 peer reviewed papers and 100 conference abstracts in several national and international conferences. He has served as a chair and co-chair of scientific sessions at the Annual National Meetings of American Association of Pharmaceutical Scientists and Society of Toxicology. He serves as an editorial board member for five journals and as a peer reviewer for more than forty journals. His field of expertise are Transdermal Drug Delivery; Nanoparticles, Solubility improvement; Ocular Drug Delivery.

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Associate Editors



Maria J. Blanco-Prieto

Department of Pharmacy and Pharmaceutical Technology
University of Navarra

Pamplona
(Spain)

[Biography](#)



Biography of Maria J. Blanco-Prieto



Maria J. Blanco-Prieto received her degree of Pharmacy Degree from the University of Santiago de Compostela (Spain), followed by a PhD in Pharmaceutical Sciences from the University of Paris-Sud (France). She completed post-doctoral training at the Swiss Federal Institute of Technology (ETH), Zürich, (Switzerland) and then joined the University of Navarra where presently she is a Full Professor of Pharmacy and Pharmaceutical Technology. Her research interest is in the field of biomaterials and advanced drug carrier systems including the design and the development of

polymer and lipid based micro- and nanoscale carriers, their biological evaluation in in vitro cell cultures and also their pharmacokinetic and dynamic impact in vivo (using relevant animal models of the diseases).

Close



Darryl T. Martin

Department of Urology
Yale University School of Medicine
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Biography of Darryl T. Martin



Dr. Darryl T. Martin is a Research Scientist at the Yale School of Medicine. He obtained his PhD from the Division of Biomedical Sciences, the Memorial University of Newfoundland in 2010. His research interests include drug delivery systems that target prostate and bladder cancers using nanoparticle-based platforms for diagnostic and therapeutic purposes.

Close



Yu Nie

Department of Biomedical Engineering
Sichuan University (SCU)
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(China)

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Biography of Yu Nie



Dr. Yu Nie obtained PhD in Pharmaceutical Sciences from West China School of Pharmacy, Sichuan University, China. She is presently serving as a Professor at NERCB, Sichuan University, China and before that she was an Assistant Professor at the same institution. She also has an experience as a postdoc fellow at Ludwig-Maximilian-University of Munich, Germany. Her research interests include Regenerated bio-materials, medicinal excipients in ophthalmology and Orthopedics. She has contributed more than 50 publications, having citations around 1050.

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Regional Editors

Asia



Farid Dorkoosh

Department of Pharmaceutics
Tehran University of Medical Sciences
Tehran
(Iran)

[Biography](#)

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Biography of Farid Dorkoosh



Dr. Dorkoosh received his PhD in pharmaceutics and biopharmaceutics from Leiden University, the Netherlands in 2002. He followed an international training on intellectual property and management of innovation at World Intellectual Property Organization (WIPO) in Geneva, Switzerland in 2005. He got his Diploma in management from Chartered Management Institute of London, UK in 2009. He is currently an associate professor at Tehran University of Medical Sciences. He is also the head of Patent office of Tehran University of Medical Sciences. Dr. Dorkoosh has published more than 80 research articles and held 10 patents and patent applications.

Close



Murugan Ramalingam

Centre for Stem Cell Research
Christian Medical College Campus
Vellore
(India)

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Biography of Murugan Ramalingam



Dr. Murugan Ramalingam is a Professor at the Centre for Stem Cell Research (India). Concurrently, he is an Adjunct Professor at the Tohoku University (Japan). He worked as Associate Professor at the Université de Strasbourg (France) and Assistant Professor at the WPI-Advanced Institute for Materials Research (Japan). He has also worked at the U.S. National Institute of Standards and Technology (NIST) and the National Institutes of Health (NIH). He received his Ph.D. in Biomaterials from the University of Madras. He is the author of over 260 scientific publications.

Close

Europe



Clare Hoskins

Director of Postgraduate Research Medical Sciences (Laboratory)
Keele University
Newcastle, England
(United Kingdom)

[Biography](#)

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Biography of Clare Hoskins



Dr. Clare Hoskins obtained PhD in Pharmaceutics from Robert Gordon University, Aberdeen. She is presently serving as a Senior Lecturer in Pharmaceutics at Keele University. She is a member of different professional bodies such as Royal Society of Chemistry, Controlled Released Society, British Nano-medicine Society and Higher Education Academy. She has contributed numerous publications in different national and international journals. She also possesses different editorial responsibilities in different journals as a guest editor and editorial board member.

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North America



Glen S. Kwon

School of Pharmacy-Wisconsin Center for NanoBioSystems
University of Wisconsin
Madison, WI
(USA)

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Biography of Glen S. Kwon



Dr. Kwon is the Jens T. Carstensen Distinguished Chair Professor in the School of Pharmacy at University of Wisconsin. He received the Jorge Heller Journal of Controlled Release/Controlled Release Society (CRS) Outstanding Paper Award (1994) and CRS Young Investigator Research Achievement Award (2003). He is a Fellow

of the American Association of Pharmaceutical Scientists (2012) and a highly-cited researcher by Thomson Reuters in the category of Pharmacology & Toxicology (2014). He is co-founder of Co-D Therapeutics Inc., a start-up company dedicated to multi-drug anticancer nanotherapeutics.

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Section Editors



Section: Biodegradable polymers for nanomedicine

Rohidas Arote

Department of Molecular Genetics
Seoul National University

Seoul
(South Korea)

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Biography of Rohidas Arote



Prof. Arote Rohidas is an Associate Professor and the director of Nanomedicine Laboratory in the Dept. of Molecular Genetics, School of Dentistry, Seoul National University. His research includes nanotechnology, drug delivery, molecular targeting, nucleic acid delivery, bioimaging and modulation of cell death mechanism has been published in over 50 international journals and also produced various patents.

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Hua Ai

Department of Radiology
Sichuan University

Chengdu
(China)



Alaa A. Aljabali
Faculty of Pharmacy
Yarmouk University
Irbid
(Jordan)
[Biography](#)

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Biography of Alaa A. Aljabali



Alaa A. Aljabali completed MRes in cancer biomarkers from Essex University and a Ph.D. in Bionanotechnology from John Innes Centre (UK). He worked as a postdoctoral research fellow at the University of Oxford on the development of nanoparticles as clinical imaging agents. Recently, he completed Fellowship in Responsible Conduct of Research at the University of California San Diego. His research interest are Biomaterials, Drug delivery and targeting, Material science, and Nanomedicine.

Close



Christine Allen
Leslie Dan Faculty of Pharmacy
University of Toronto
Toronto, ON
(Canada)
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Biography of Christine Allen



Christine Allen is the GlaxoSmithKline Chair in Pharmaceutics and Drug Delivery and a Professor in the Leslie Dan Faculty of Pharmacy and the Departments of Chemical Engineering and Applied Chemistry and IBBME at the University of Toronto. Allen's research is focused on the design and development of new materials and technologies for the delivery of drugs and contrast agents. Her research has resulted in well over 100 peer-reviewed publications, numerous patent applications and book chapters on both lipid and polymer-based drug delivery systems. She is also the co-founder and President of Nanovista Inc., a start-up housed in Johnson & Johnson Innovations J Labs @Toronto, which is focused on the development of multimodal contrast agents to improve the performance of image-guided high precision cancer therapy.

Close



Stephanie Allen
School of Pharmacy
University of Nottingham

Nottingham
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**Giulio Caracciolo**

Department of Molecular Medicine
University of Rome
Rome
(Italy)

[Biography](#)

**Biography of Giulio Caracciolo**

Giulio Caracciolo is Professor at the Molecular Medicine Department of the Sapienza University of Rome. He is mainly interested in understanding the bio–nano interactions between nanodelivery systems and physiological environments. The relationships between synthetic identity, biological identity and physiological response of drug delivery systems will enable researchers to predict their outcome after administration in vivo. This would represent a truly new paradigm in the field of pharmaceuticals and nanomedicine.

Close

**Bin Chen**

State Key Laboratory of Multiphase Flow in Power Engineering
Xi'an Jiaotong University
Xi'an Shi
(China)

[Biography](#)

**Biography of Bin Chen**

Dr. Bin Chen is now a Full Professor and Vice Director at the State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University. He received his Ph.D in 2002 from Xi'an Jiaotong University, China. Afterwards, he worked as Postdoctoral Research Fellow of Japan Society for the Promotion of Science from 2002 to 2004. For more than a decade, Dr. Chen has devoted his efforts to the research on laser dermatology, in particular with the laser treatment of Port Wine Stain. He is currently working on photothermal-activatable liposomal drug delivery, blood absorption enhancement by nano-particle, as well as animal experiment on thermal damage of blood capillary by 595nm and 1064nm laser. He has published over 50 peer-reviewed journal papers and was invited for more than 20 keynote speeches.

Close

**Pieter Cullis**

Biochemistry and Molecular Biology
University of British Columbia
Vancouver, BC
(Canada)

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Biography of Pieter Cullis

Pieter R. Cullis, Ph.D. FRSC is the Director of Life Sciences Institute at the University of British Columbia (UBC) He is a Professor in the Department of Biochemistry and Molecular Biology and Director of the, NanoMedicines Research Group, UBC. Dr. Cullis and co-workers made fundamental advances in the generation, loading and targeting of lipid nanoparticle (LNP) systems for intravenous delivery of small molecule drugs and macromolecular drugs such as small interfering RNA (siRNA). This work has contributed to three drugs that have been approved by regulatory agencies in the U.S. and Europe for the treatment of cancer and its complications. Dr. Cullis has co-founded ten biotechnology companies, has published over 300 scientific articles and is an inventor of over 60 patents. He also co-founded the BC Personalized Medicine Initiative in 2012. Dr. Cullis received many awards and was elected as the Fellow of the Royal Society of Canada in 2004 and was awarded the Prix Galien, Canada's premier prize for achievements in pharmaceutical R&D, in 2011.

Close

**Sudip Das**

Department of Pharmaceutics & Drug Delivery
Butler University, College of Pharmacy and Health Sciences
Indianapolis, IN
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Biography of Sudip Das

Dr. Sudip Das is a professor of pharmaceutical sciences at Butler University, College of Pharmacy & Health Sciences. He is also an Adjunct Professor in the School of Medicine, Indiana University. He was the chair of the department of pharmaceutical sciences and the director of the graduate program in pharmaceutical sciences at Butler University. Dr. Das has over thirty years of teaching and research experience in the professional pharmacy and graduate programs in the USA and Canada. His current research involves targeted delivery of siRNA and anticancer drugs for the treatment of breast cancer and glioblastoma. Dr. Das has over 150 research publications, review articles, patents, proceedings, conference presentations, and book chapters, is a recipient of multiple awards/honors, and has secured

extramural research funding from NIH, PDA, and several pharmaceutical industries.

Close



Nunzio Denora

Department of Pharmacy
University of Bari Aldo Moro
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[Biography](#)

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Biography of Nunzio Denora



Nunzio Denora received the degree in Chemistry and Pharmaceutical Technology from the University of Bari in 2001 and obtained his Ph.D. in Pharmaceutical Technology from the University of Palermo in 2004. After a postdoctoral position in the Department of Pharmaceutical Chemistry at Kansas University (2005-2006), he was appointed as assistant professor and research scientist of Pharmaceutical Technology in the Department of Pharmacy - Drug Sciences of the University of Bari. He has published more than 80 articles, is author of 3 book chapters, more than 100 posters and several oral presentations and is inventor of 3 patents.

Close



Christine Dufès

Strathclyde Institute of Pharmacy and Biomedical Sciences
University of Strathclyde
Glasgow
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Biography of Christine Dufès



Dr. Christine Dufès is a Senior Lecturer at the Strathclyde Institute of Pharmacy and Biomedical Sciences (SIPBS), University of Strathclyde, Glasgow, United Kingdom. She obtained a Doctorate in Pharmacy and a PhD from the University of Poitiers (France). Her research interests include the targeted delivery of drugs and therapeutic genes to tumours and cerebral diseases. She has been awarded the Biochemical Journal Young Investigator Award (2009) and the Tom Gibson Memorial Award (2012) for her research, in addition to the Best Overall Strathclyde Teaching Excellence Award 2013 for her teaching. She sits on the editorial boards for 17 journals.

Close

**Martin J. D'Souza**

Vaccine Nanotechnology Laboratory
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[Biography](#)

**Biography of Martin J. D'Souza**

Dr. Martin J. D'Souza obtained his Ph.D. degree (1987) in Pharmaceutical Sciences from the University of Pittsburgh, Pittsburgh, PA, USA. Dr. D'Souza is currently performing numerous roles at Mercer University, Atlanta, GA, USA, i.e. Professor & Director of Graduate Programs in the College of Pharmacy. He is the Director of Mercer Clinical Laboratory, Co-Director of the Center for Drug Delivery Research, and Chair of the Pharmaceutics. He is the co-founder of Drug Delivery Therapeutics. His main fields of specialization include Vaccines, Pharmacokinetics, Bio-pharmaceutics, Bio-technology, etc.

Close

**Biana Godin**

Department of Nanomedicine
The Methodist Hospital Research Institute
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**Khaled F. Greish**

Department of Molecular medicine
Arabian Gulf University
Manama
(Bahrain)

[Biography](#)

**Biography of Khaled F. Greish**

Khaled Greish is Associate Professor of Molecular Medicine, and head of the Nano-research unit, at Princes Al-Jawhara Centre, Arabian Gulf University, Kingdom of Bahrain, and Adjunct Associate Professor of Pharmaceutical Chemistry at University of Utah, USA. He Published > 70 peer reviewed papers, and 10 book chapters in the field of targeted anticancer drug delivery. Controlled Release Society (CRS) awarded him the CRS Postdoctoral Achievement award in 2008 and in 2010; he

was elected as the member of the CRC College of Fellows in 2014 at the University of Otago.

Close



Zhong Gu

National Engineering Research Center for Biomaterials
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Biography of Zhong Gu



Professor Zhongwei Gu graduated from Peking University in 1981 and served as a senior visiting scholar in the Research Triangle Institute, RTP and the University of Utah, USA, respectively from 1984 to 1986 and 1991 to 1993. He was appointed as a Professor in 1994, and has thrice been the Chief Scientist of the National Basic Research Program of China (the 973 program) since 1999. He is a Fellow of International Union of Societies for Biomaterials Science and Engineering (FBSE). His current research activities focus on the biomedical polymers, nano-biomaterials and drug delivery systems and tissue engineering.

Close



Jianfeng Guo

School of Pharmaceutical Sciences
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[Biography](#)

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Biography of Jianfeng Guo



Dr. Jianfeng Guo, Ph.D., is a Professor of Nanomedicine at School of Pharmaceutical Sciences, Jilin University, China. He received his PhD in 2011 from University College Cork (UCC), Ireland. He was a Research Fellow at University of Michigan, Ann Arbor, followed by industrial working experience at the Viva Biotech Ltd., Shanghai, as a Project Manager. He then spent three years at UCC as a Senior Research Fellow, prior to joining in Jilin University in 2016. He was awarded the Embark Initiative Postgraduate Scholarship, Chinese Government Award for Outstanding Self-financed Students Abroad. Dr. Jianfeng Guo has published 24 peer-reviewed scientific articles.

Close

**Umesh Gupta**

Department of Pharmacy
Central University of Rajasthan
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(India)

[Biography](#)

**Biography of Umesh Gupta**

Dr. Umesh Gupta, currently working as Assistant Professor in the Department of Pharmacy, Central University of Rajasthan, India. He did Ph.D. in Pharmaceutical Sciences from Dr. H. S. Gour University, Sagar, India under the mentorship of Prof. NK Jain. He has recently been awarded “DAAD Research Stays for Academics and Scientists” at Leibniz-institut fur Polymerforschung Dresden, Germany. He has the past experience of working as Research Scientist at Ranbaxy Research Laboratories, India and Post-Doctoral Research Associate at South Dakota State University, USA. He joined the Central University of Rajasthan in the year 2013.

Close

**Lisbeth Illum**

IDentity - Pharmaceutical Consultancy
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[Biography](#)

**Biography of Lisbeth Illum**

Professor Lisbeth Illum was the founder and Managing Director of DanBioSyst UK Ltd a drug delivery technology company, sold successfully to West Pharmaceutical Services and now Archimedes Lab Ltd. She was the CEO of Critical Pharmaceuticals Ltd a drug delivery company. She now works as a consultant to the pharmaceutical industry and expert witness in patent litigations. She was awarded M. Pharm, Ph. D and D.Sc. from the Royal Danish School of Pharmacy in 1972, 1978 and 1988, respectively. Her research expertise is in the area of novel drug delivery systems for difficult drugs, such as hydrophilic and insoluble drugs, peptide and proteins. She has published more than 350 scientific papers, co-edited four books and filed more than 45 patent family applications on novel drug delivery systems, of which a large number of patents have been granted. She has lectured extensively throughout the world at conferences and workshops. She is a Fellow of the AAPS and CRS. She has been on the editorial boards of eleven scientific journals.

Close

**Kazunori Kataoka**

Department of Materials Engineering
University of Tokyo
Tokyo
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**Xin-Gui Li**

College of Environmental Science & Engineering
Tongji University
Shanghai
(China)

[Biography](#)

**Biography of Xin-Gui Li**

Dr. Xinn- Guii Lii obtained PhD in Polymer Materials from China Textile University, Shanghai. He is presently serving as Professor of Polymer Materials and Director of Inst. of Mater Chem at Tongji University, Shanghai, China. He has been recognized with many awards and honors such as ACS Membership Award in 2015, Natural Science Prize in 2015 and many other awards. He is also a member of different organizations such as ACS, National Engineering Research Center of Electronic Circuits Base Materials of China, Key Laboratory of Advanced Polymer Materials, Shanghai, China, Educational Ministry of China, and Shanghai Key Laboratory for Advanced Polymer Materials.

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**Ulrich Lächelt**

Department of Pharmacy
Ludwig Maximilian University of Munich
Munich
(Germany)

[Biography](#)

**Biography of Ulrich Lächelt**

Ulrich Lächelt studied pharmaceuticals at the University of Heidelberg and received a doctoral degree in Pharmaceutical Biology at the LMU Munich in 2014. He worked on multifunctional sequence-defined nucleic acid carriers together with Prof. Ernst Wagner. Since 2017 he continues the research on drug delivery and nanomedicine as junior research group leader and candidate for habilitation. He is an extraordinary member of the Center for NanoScience (CeNS) at the LMU. His research

focuses on the intracellular delivery of biomacromolecules, such as nucleic acids, peptides and proteins, the development of drug conjugates and inorganic-organic hybrid nanopharmaceuticals.

Close



Achuthamangalam B. Madhankumar

Department of Neurosurgery
Pennsylvania State University
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(USA)



Tamara Minko

Department of Pharmaceutics
Rutgers University
Piscataway, NJ
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Biography of Tamara Minko



Tamara Minko, Ph.D., is a Distinguished Professor and Chair of the Department of Pharmaceutics at Rutgers University. Her current research interests include nanotechnology; drug delivery; personalized nanomedicine; molecular targeting; nucleic acids delivery; mechanisms of multidrug resistance; bioimaging; preclinical evaluation of new therapeutics; and modulation of cell death mechanisms during hypoxia. Professor Minko is author and coauthor of more than 400 publications. Dr. Minko is an elected Fellow of CRS, AAPS, and AIMBE; recipient of numerous awards. She also is an Executive Editor of *Advanced Drug Delivery Reviews*, Editor of *Pharmaceutical Research*, President-Elect of the Controlled Release Society.

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Teresa Musumeci

Department of Drug Science
University of Catania
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Biography of Teresa Musumeci



Teresa Musumeci is an assistant professor and research scientist in the Department of Drug Sciences at the University of Catania, since 2008. Teresa Musumeci received her Pharmacy degree from the University of Catania (Italy) in 2001. She received her PhD in Pharmaceutical Technology from the University of Palermo (Italy) in 2007. She is the author of 30 per-reviewed papers and 2 book chapters. Her scientific activity is focused on design and characterization of nanocarriers for delivery of drugs.

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Caitriona O'Driscoll

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University College Cork
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Kamla Pathak

Department of Pharmaceutics
Uttar Pradesh University of Medical Sciences
Etawah
(India)

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Biography of Kamla Pathak



Professor Kamla Pathak, Professor and Head of the Department of Pharmaceutics, Pharmacy College Saifai, U. P. RIMS&R, Saifai, Etawah, India has a teaching and research experience of more than 26 years. She is actively engaged in research on oral controlled /modulated/targeted and topical drug delivery systems. She has over 200 publications in journals of international and national repute, 3 patents, authored book chapters and more than 180 abstracts of the papers presented in scientific forums to her credit. She has supervised Ph.Ds, more than 120 postgraduate theses and has a h-index of 21.

Close



Qiang Peng

West China Hospital of Stomatology
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Biography of Qiang Peng



Dr. Qiang Peng obtained his B.S. degree (2006), M.A. degree (2009), and Ph.D in pharmaceutics (2012) from Sichuan University, China. He joined West China Hospital of Stomatology, Sichuan University as a lecturer in 2012 and promoted as an associate professor in 2014. Dr. Peng once worked in Keele University from 2010 to 2011 and in University of Copenhagen during 2015. His research focuses on nanomaterials-based advanced drug delivery. As a young scientist, he has published more than 20 publications. He won the Sichuan Provincial Award of Outstanding PhD Dissertation in 2014 and the First Prize of Chinese Outstanding Young Investigator Award, IADR-China Division in 2014.

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Stefano Salmaso

Department of Pharmaceutical and Pharmacological Sciences
University of Padova
Padova
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Biography of Stefano Salmaso



Stefano Salmaso is associate professor in the Department of Pharmaceutical and Pharmacological Sciences of the University of Padova (Italy), where he teaches Technology of delivery and controlled release of drugs. He obtained his Ph.D. in Pharmaceutical Sciences in 2004 and the Master degree in Chemistry and Pharmaceutical Technology from the University of Padova. He held positions as assistant professor at the University of Padova and associate scientist at Northeastern University - Boston (USA) in 2005 and 2008. He is author of 58 peer-reviewed publications, 3 book chapters, and inventors of 3 international patents. His scientific activity is focused on the development of responsive “smart” nanocarriers for the delivery of drugs and biopharmaceutics.

Close



Helder Santos

Division of Pharmaceutical Technology, Faculty of Pharmacy
University of Helsinki
Helsinki
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Biography of Helder Santos

Dr. Santos obtained a doctorate (D.Sc.) in Chemical Engineering from the Helsinki University of Technology, Helsinki, Finland. Currently Dr. Santos is an



Adjunct Professor in Pharmaceutical Nanotechnology at the University of Helsinki, Finland. He has published more than 150 scientific publications. Dr. Santos serves as Editor and is in the Editorial Board of several international journals.

Close



Sevda Senel

Department of Pharmaceutical Technology
Ankara University
Ankara
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Biography of Sevda Senel



Sevda Şenel is Professor at the School of Pharmacy at Hacettepe University, Ankara Turkey. Numerous international (NATO-CRG, NATO-CLG, British Council, EU-7-SME) and national (TUBITAK, SAN-TEZ) projects led her group to the development of non-invasive systems for drugs and vaccines via various mucosae (buccal, sublingual and nasal) in human and veterinary field. Dr. Şenel and her research group has been awarded a number of prestigious honors including AAPS-PharmSciTech Best Poster Award (2015), Hacettepe University Science Award (2011), The Distinguished Scientist Award - by the Academy of Science of the Turkish Pharmacists Association (2010), CRSIntervet Best Veterinary Paper Award (2005) and the Novartis Pharmaceutical Technology Research Award (2004). Dr. Şenel is the author of more than 150 research publications, which includes original research and book chapters.

Close



Amanda K.A. Silva

Laboratoire Matière et Systèmes Complexes (UMR 7057)
Paris Diderot University
Paris
(France)

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Biography of Amanda K.A. Silva



Amanda K. A. Silva obtained a degree in Pharmacy in 2005 at UFRN, Brazil, and a PhD in Pharmaceutical Technology in 2008 in the domain of gastro-resistant magnetic microcapsules. She obtained a second PhD in Cellular and Molecular Biology in 2010 from the Université d'Evry, France concerning polysaccharides for thermo-controlled cell culture in 3D. In 2013, Amanda obtained a tenured CNRS

researcher position at Matter and Complex Systems lab in Paris. She works in physical approaches for regenerative medicine, extracellular vesicle engineering, theranosis and photo-activated therapies. Amanda has published 37 papers and is an inventor in 4 patents.

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Vladimir P. Torchilin

Center for Pharmaceutical Biotechnology and Nanomedicine
Northeastern University

Boston, MA

(USA)

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Biography of Vladimir P. Torchilin



Vladimir P. Torchilin, Ph.D., D.Sc. is a University Distinguished Professor of Pharmaceutical Sciences and Director, Center for Pharmaceutical Biotechnology and Nanomedicine, Northeastern University, Boston. His interests include drug delivery and targeting, nanomedicine, multifunctional and stimuli-sensitive pharmaceutical nanocarriers, biomedical polymers, experimental cancer therapy. He has published more than 400 original papers, more than 150 reviews and book chapters, wrote and edited 12 books, and holds more than 40 patents. Google Scholar has shown more than 44,000 citations of his papers with an H-index of 96. He is Editor-in-Chief of Current Drug Discovery Technologies, Drug Delivery, and OpenNano, Co-Editor of Current Pharmaceutical Biotechnology and on the Editorial Boards of many other journals. He received more than \$30 M from the governmental and industrial sources in research funding. He has multiple honors and awards and in 2011, Times Higher Education ranked him number 2 among the top world scientists in pharmacology for the period of 2000-2010.

Close



Ernst Wagner

Department of Pharmacy, and Center for Nanoscience (CeNS)

Ludwig-Maximilians-Universität (LMU)

Munich

(Germany)

[Biography](#)

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Biography of Ernst Wagner

Dr. Wagner is Professor of Pharmaceutical Biotechnology at Ludwig-Maximilians-Universität Munich and a member of the Munich Center for Nanoscience. He coordinates 'Biomedical Nanotechnologies' of the Excellence



Cluster 'Nanosystems Initiative Munich'. After a Ph.D. in Chemistry from the Technical University of Vienna and a postdoctoral stay at the ETH Zurich, he was the group leader at the IMP Vienna and Director for Cancer Vaccines at Boehringer Ingelheim Austria. Dr. Wagner has authored more than 390 publications with an h-index 70. He has been a board member of the German Society for Gene Therapy, Committee member of ASGCT, and BSA member of the CRS.

Close



Roderick Bryan Walker
Division of Pharmaceutics
Rhodes University
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(South Africa)

[Biography](#)

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Biography of Roderick Bryan Walker



Professor Walker completed his Ph.D. degree in Biopharmaceutics and Pharmacokinetics at Rhodes University in Grahamstown, South Africa. He is the former Dean and Head of the Faculty of Pharmacy at Rhodes and is currently the Professor of Pharmaceutics and is the current chair of the Academy of Pharmaceutical Sciences in South Africa. Professor Walker has published and presented over 200 scientific outputs and serves on the editorial boards of a number of journals. Professor Walker undertakes research studies in all aspects of drug delivery and product development.

Close



Zimei Wu
School of Pharmacy
University of Auckland
Auckland
(New Zealand)

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Biography of Zimei Wu



Zimei Wu is an Associate Professor at the School of Pharmacy, University of Auckland, New Zealand (NZ). She holds a PhD from University of Otago (NZ) and a Masters from China Pharmaceutical University. Her 'liposomes' research has attracted wide collaborations. She received an NZ-China Scientist Exchange Award from the Royal Society of NZ. She also researches transdermal delivery with successful stories featured on NZ TV3. Zimei also serves on editorial boards of

Journal of Liposome Research, and Pharmaceutical Development and Technology and a referee for >20 journals. Zimei was the past President of NZ Local Chapter of Controlled Release Society.

Close



Shirley Wu

Department of Pharmaceutical Sciences
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Sarita K. Yadav

Department of Pharmacy
MLN Medical College Prayagraj
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(India)

[Biography](#)

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Biography of Sarita K. Yadav



Dr. Sarita K Yadav obtained her B. Pharm from DIPSAR and earned her M. Pharm and Ph.D. from IIT(BHU), India. Currently, she is working as Assistant Professor at MLN Medical College, Prayagraj. She has qualified GATE 2009 with AIR-32. She had worked for two years as drug analyst in testing of drugs and cosmetics products at UPFSDA, Lucknow. She had received “Young Scientist Award-WF” in 2015 by SPER for her research contributions. She holds lifetime membership of APTI, IPGA, SPER, and PRISAL. She is a member of editorial board of Micro and Nano System (MNS) by Bentham Science, IJBST journal group and peer reviewer in Future Journal of Pharmaceutical Sciences, Saudi Pharmaceutical Journal etc. Currently, she has many research/reviews papers to her credit in high impact journals with total impact factor around 60.

Close



Yanjun Zhao

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[Biography](#)

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Biography of Yanjun Zhao



Prof. Zhao is a Full Professor of Pharmaceutics in the School of Pharmaceutical Science and Technology, Health Science Platform, Tianjin University. He obtained the Bachelor (Polymer), Master (Engineering), and PhD (Pharmacy) degree from Dalian University of Technology, Dalian Institute of Chemical Physics (CAS), and King's College London, respectively. His research interests focus on pharmaceutical micelles, stimuli-responsive drug delivery, and ferroptosis antitumor nanomedicine.

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Associate Editorial Board Members



Goutam Mondal

Postdoctoral Research Associate
National Center for Natural Products Research
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Oxford, MS
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[Biography](#)

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Biography of Goutam Mondal



Dr. Goutam Mondal is an emerging pharmaceutics and drug delivery scientist. He is an expert in the design and synthesis of receptor targeted lipids and polymeric systems, the techniques of animal tissue culture, tumor growth inhibition studies, and pharmacokinetics studies of small molecules. Presently, he is associated with Dr. Ikhlas A Khan's research group under supervision of Dr. Ryan Yates at the National Center for Natural Products Research, University of Mississippi, USA where he is actively involved in pre-clinical and clinical pharmacokinetics and pharmacodynamics of natural products. He has published 21 research articles in high impact peer-reviewed journals.

Close



Mariane L. Nogueira

Department of Pharmacy
Federal University of Pernambuco
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[Biography](#)

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Biography of Mariane L. Nogueira



Dr. Mariane Lira Nogueira is a Pharmacist. She obtained Master's degree in Pharmaceutical Sciences, and Ph.D. in Biological Sciences with an emphasis on Biotechnology. She completed an interuniversity exchange doctorate in Pharmacotechnics (2007-2008) at the Faculté de Pharmacie - Université Paris Sud 11 and an internship at the Universidad de Navarra (2008). She did Post-doc from the Université Paris Saclay (2014-2015). She is currently an Associate Professor at the Federal University of Pernambuco, Brazil, a researcher at the Keizo-Asami Immunopathology Laboratory, and leader of Nanotechnology, Biotechnology, and Cell Culture Research Group. Her research fields are mainly focused on the development and characterization of surface-modified nanocarriers for biomedical applications.

Close



Meysam Omid

Protein Research Centre
Shahid Beheshti University G.C.
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[Biography](#)

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Biography of Meysam Omid



Dr. Meysam Omid is an Assistant Professor of Protein Research Center, Shahid Beheshti University. Dr. Omid's research is focused on application of nanobiomaterials in soft, hard, and interfacial tissue engineering. He is particularly interested to design and fabricate smart nano drug delivery systems for regenerative medicine application. He has (co)authored over 80 research papers in the field of nanoscience and nanotechnology.

Close



Aniruddha Roy

Department of Pharmacy
Birla Institute of Technology and Science
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[Biography](#)

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Biography of Aniruddha Roy

Dr. Aniruddha Roy is currently working as an Assistant Professor in the Department of Pharmacy at Birla Institute of Technology and Science (BITS) -



Pilani, India. He is a Pharmaceutical Technologist by training. He completed PhD in Immunology from National Institute of Immunology (NII), New Delhi, India. His main area of PhD thesis work was immunotherapy of cancer. After PhD, he worked at the Indian Institute of Technology, New Delhi, Ontario Institute for Cancer Research at the University of Toronto, Canada, and University of British Columbia, Canada in various capacities. He has more than ten years of research experience. His research is primarily focused on nanomedicine and targeted drug delivery in different diseases.

Close

Executive Guest Editor(s)



Ismail Ocsoy

Department of Analytical Chemistry
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Biography of Ismail Ocsoy



Dr. Ismail Ocsoy is a Professor in the faculty of Pharmacy, Erciyes University, Kayseri, Turkey. He completed his MS and Ph.D. in Chemistry from the Department of Chemistry, University of Florida, USA. His research focuses on Nano biotechnology consisting of DNA Aptamer conjugated nanomaterial, cancer therapy models, anti-cancer, antimicrobial agents and Nano bio-sensor for detection of antibiotic resistant bacteria. He has published more than 70 papers in highly reputable and prestigious journals.

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Editor-in-Chief



Zongjin Li

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[Biography](#)

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Biography of Zongjin Li



Dr. Zongjin Li is a Professor at the Department of Pathophysiology and a Director of the Laboratory of Molecular Imaging and Stem Cell Therapy at Nankai University School of Medicine, Tianjin, China. He received his PhD degree from Peking Union Medical College and completed his postdoctoral training in the Molecular Imaging Program (MIPS) at Stanford University, USA. He has published more than 120 peer-reviewed papers on molecular imaging and stem cell therapy.

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Co-Editors



Jay B. Ramapuram

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Harrison School of Pharmacy
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[Biography](#)

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Biography of Jay B. Ramapuram



Dr. Ramapuram Jayachandra Babu is currently a Professor and Graduate Program Officer at the Department of Drug Discovery and Development, Harrison School of Pharmacy, Auburn University. He received his Bachelor's degree in Pharmacy from the University of Madras and Masters and PhD degrees in Pharmaceutics from Indian Institute of Technology, Varanasi, India. His research interests include formulation development of nanoparticle based formulations for topical and oral delivery, solubility improvement of insoluble drugs, percutaneous penetration enhancement techniques, and transdermal drug delivery systems. He has authored and co-authored over 90 peer reviewed papers and 100 conference abstracts in several national and international conferences. He has served as a chair and co-

chair of scientific sessions at the Annual National Meetings of American Association of Pharmaceutical Scientists and Society of Toxicology. He serves as an editorial board member for five journals and as a peer reviewer for more than forty journals. His field of expertise are Transdermal Drug Delivery; Nanoparticles, Solubility improvement; Ocular Drug Delivery.

Close

Associate Editors



Maria J. Blanco-Prieto

Department of Pharmacy and Pharmaceutical Technology
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Biography of Maria J. Blanco-Prieto



Maria J. Blanco-Prieto received her degree of Pharmacy Degree from the University of Santiago de Compostela (Spain), followed by a PhD in Pharmaceutical Sciences from the University of Paris-Sud (France). She completed post-doctoral training at the Swiss Federal Institute of Technology (ETH), Zürich, (Switzerland) and then joined the

University of Navarra where presently she is a Full Professor of Pharmacy and Pharmaceutical Technology. Her research interest is in the field of biomaterials and advanced drug carrier systems including the design and the development of polymer and lipid based micro- and nanoscale carriers, their biological evaluation in in vitro cell cultures and also their pharmacokinetic and dynamic impact in vivo (using relevant animal models of the diseases).

Close



Darryl T. Martin

Department of Urology
Yale University School of Medicine
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[Biography](#)

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Biography of Darryl T. Martin

Dr. Darryl T. Martin is a Research Scientist at the Yale School of Medicine. He obtained his PhD from the Division of Biomedical Sciences, the Memorial University of Newfoundland in 2010. His research interests include drug delivery



systems that target prostate and bladder cancers using nanoparticle-based platforms for diagnostic and therapeutic purposes.

Close



Yu Nie

Department of Biomedical Engineering
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[Biography](#)

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Biography of Yu Nie



Dr. Yu Nie obtained PhD in Pharmaceutical Sciences from West China School of Pharmacy, Sichuan University, China. She is presently serving as a Professor at NERCB, Sichuan University, China and before that she was an Assistant Professor at the same institution. She also has an experience as a postdoc fellow at Ludwig-Maximilian-University of Munich, Germany. Her research interests include Regenerated bio-materials, medicinal excipients in ophthalmology and Orthopedics. She has contributed more than 50 publications, having citations around 1050.

Close

Regional Editors

Asia



Farid Dorkoosh

Department of Pharmaceutics
Tehran University of Medical Sciences
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[Biography](#)

×

Biography of Farid Dorkoosh

Dr. Dorkoosh received his PhD in pharmaceutics and biopharmaceutics from Leiden University, the Netherlands in 2002. He followed an international training on intellectual property and management of innovation at World Intellectual Property Organization (WIPO) in Geneva, Switzerland in 2005.



He got his Diploma in management from Chartered Management Institute of London, UK in 2009. He is currently an associate professor at Tehran University of Medical Sciences. He is also the head of Patent office of Tehran University of Medical Sciences. Dr. Dorkoosh has published more than 80 research articles and held 10 patents and patent applications.

Close



Murugan Ramalingam
Centre for Stem Cell Research
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[Biography](#)

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Biography of Murugan Ramalingam



Dr. Murugan Ramalingam is a Professor at the Centre for Stem Cell Research (India). Concurrently, he is an Adjunct Professor at the Tohoku University (Japan). He worked as Associate Professor at the Université de Strasbourg (France) and Assistant Professor at the WPI-Advanced Institute for Materials Research (Japan). He has also worked at the U.S. National Institute of Standards and Technology (NIST) and the National Institutes of Health (NIH). He received his Ph.D. in Biomaterials from the University of Madras. He is the author of over 260 scientific publications.

Close

Europe



Clare Hoskins
Director of Postgraduate Research Medical Sciences (Laboratory)
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[Biography](#)

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Biography of Clare Hoskins

Dr. Clare Hoskins obtained PhD in Pharmaceutics from Robert Gordon University, Aberdeen. She is presently serving as a Senior Lecturer in Pharmaceutics at Keele University. She is a member of different professional bodies such as Royal Society of Chemistry, Controlled Released Society,



British Nano-medicine Society and Higher Education Academy. She has contributed numerous publications in different national and international journals. She also possesses different editorial responsibilities in different journals as a guest editor and editorial board member.

Close

North America



Glen S. Kwon

School of Pharmacy-Wisconsin Center for NanoBioSystems
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[Biography](#)

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Biography of Glen S. Kwon



Dr. Kwon is the Jens T. Carstensen Distinguished Chair Professor in the School of Pharmacy at University of Wisconsin. He received the Jorge Heller Journal of Controlled Release/Controlled Release Society (CRS) Outstanding Paper Award (1994) and CRS Young Investigator Research Achievement Award (2003). He is a Fellow of the American Association of Pharmaceutical Scientists (2012) and a highly-cited researcher by Thomson Reuters in the category of Pharmacology & Toxicology (2014). He is co-founder of Co-D Therapeutics Inc., a start-up company dedicated to multi-drug anticancer nanotherapeutics.

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Section Editors



Biodegradable polymers for nanomedicine

Rohidas Arote

Department of Molecular Genetics
Seoul National University
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[Biography](#)



Biography of Rohidas Arote



Prof. Arote Rohidas is an Associate Professor and the director of Nanomedicine Laboratory in the Dept. of Molecular Genetics, School of Dentistry, Seoul National University. His research includes nanotechnology, drug delivery, molecular targeting, nucleic acid delivery, bioimaging and modulation of cell death mechanism has been published in over 50 international journals and also produced various patents.

Close

Editorial Board Members



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Alaa A. Aljabali
Faculty of Pharmacy
Yarmouk University
Irbid
(Jordan)
[Biography](#)



Biography of Alaa A. Aljabali



Alaa A. Aljabali completed MRes in cancer biomarkers from Essex University and a Ph.D. in Bionanotechnology from John Innes Centre (UK). He worked as a postdoctoral research fellow at the University of Oxford on the development of nanoparticles as clinical imaging agents. Recently, he completed Fellowship in Responsible Conduct of Research at the University of California San Diego. His research interest are Biomaterials, Drug delivery and targeting, Material science, and Nanomedicine.

Close



Christine Allen
Leslie Dan Faculty of Pharmacy
University of Toronto
Toronto, ON

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[Biography](#)

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Biography of Christine Allen



Christine Allen is the GlaxoSmithKline Chair in Pharmaceutics and Drug Delivery and a Professor in the Leslie Dan Faculty of Pharmacy and the Departments of Chemical Engineering and Applied Chemistry and IBBME at the University of Toronto. Allen's research is focused on the design and development of new materials and technologies for the delivery of drugs and contrast agents. Her research has resulted in well over 100 peer-reviewed publications, numerous patent applications and book chapters on both lipid and polymer-based drug delivery systems. She is also the co-founder and President of Nanovista Inc., a start-up housed in Johnson & Johnson Innovations JLABs @Toronto, which is focused on the development of multimodal contrast agents to improve the performance of image-guided high precision cancer therapy.

Close



Stephanie Allen

School of Pharmacy
University of Nottingham
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Giulio Caracciolo

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University of Rome
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[Biography](#)

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Biography of Giulio Caracciolo



Giulio Caracciolo is Professor at the Molecular Medicine Department of the Sapienza University of Rome. He is mainly interested in understanding the bio-nano interactions between nanodelivery systems and physiological environments. The relationships between synthetic identity, biological identity and physiological response of drug delivery systems will enable researchers to predict their outcome after administration in vivo. This would represent a truly new paradigm in the field of pharmaceutics and nanomedicine.

Close

**Bin Chen**

State Key Laboratory of Multiphase Flow in Power Engineering
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[Biography](#)

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Biography of Bin Chen

Dr. Bin Chen is now a Full Professor and Vice Director at the State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University. He received his Ph.D in 2002 from Xi'an Jiaotong University, China. Afterwards, he worked as Postdoctoral Research Fellow of Japan Society for the Promotion of Science from 2002 to 2004. For more than a decade, Dr. Chen has devoted his efforts to the research on laser dermatology, in particular with the laser treatment of Port Wine Stain. He is currently working on photothermal-activatable liposomal drug delivery, blood absorption enhancement by nano-particle, as well as animal experiment on thermal damage of blood capillary by 595nm and 1064nm laser. He has published over 50 peer-reviewed journal papers and was invited for more than 20 keynote speeches.

Close

**Pieter Cullis**

Biochemistry and Molecular Biology
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(Canada)

[Biography](#)

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Biography of Pieter Cullis

Pieter R. Cullis, Ph.D. FRSC is the Director of Life Sciences Institute at the University of British Columbia (UBC) He is a Professor in the Department of Biochemistry and Molecular Biology and Director of the, NanoMedicines Research Group, UBC. Dr. Cullis and co-workers made fundamental advances in the generation, loading and targeting of lipid nanoparticle (LNP) systems for intravenous delivery of small molecule drugs and macromolecular drugs such as small interfering RNA (siRNA). This work has contributed to three drugs that have been approved by regulatory agencies in the U.S. and Europe for the treatment of cancer and its complications. Dr. Cullis has co-founded ten biotechnology companies, has published over 300 scientific articles and is an inventor of over 60 patents. He also co-founded the BC Personalized Medicine Initiative in 2012. Dr. Cullis received many awards and was elected as the Fellow of the Royal Society of Canada in 2004 and was awarded the Prix Galien, Canada's premier prize for achievements in pharmaceutical R&D, in 2011.

Close

**Sudip Das**

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[Biography](#)

**Biography of Sudip Das**

Dr. Sudip Das is a professor of pharmaceutical sciences at Butler University, College of Pharmacy & Health Sciences. He is also an Adjunct Professor in the School of Medicine, Indiana University. He was the chair of the department of pharmaceutical sciences and the director of the graduate program in pharmaceutical sciences at Butler University. Dr. Das has over thirty years of teaching and research experience in the professional pharmacy and graduate programs in the USA and Canada. His current research involves targeted delivery of siRNA and anticancer drugs for the treatment of breast cancer and glioblastoma. Dr. Das has over 150 research publications, review articles, patents, proceedings, conference presentations, and book chapters, is a recipient of multiple awards/honors, and has secured extramural research funding from NIH, PDA, and several pharmaceutical industries.

Close

**Nunzio Denora**

Department of Pharmacy
University of Bari Aldo Moro
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[Biography](#)

**Biography of Nunzio Denora**

Nunzio Denora received the degree in Chemistry and Pharmaceutical Technology from the University of Bari in 2001 and obtained his Ph.D. in Pharmaceutical Technology from the University of Palermo in 2004. After a postdoctoral position in the Department of Pharmaceutical Chemistry at Kansas University (2005-2006), he was appointed as assistant professor and research scientist of Pharmaceutical Technology in the Department of Pharmacy - Drug Sciences of the University of Bari. He has published more than 80 articles, is author of 3 book chapters, more than 100 posters and several oral presentations and is inventor of 3 patents.

Close

**Christine Dufès**

Strathclyde Institute of Pharmacy and Biomedical Sciences
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[Biography](#)

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Biography of Christine Dufès

Dr. Christine Dufès is a Senior Lecturer at the Strathclyde Institute of Pharmacy and Biomedical Sciences (SIPBS), University of Strathclyde, Glasgow, United Kingdom. She obtained a Doctorate in Pharmacy and a PhD from the University of Poitiers (France). Her research interests include the targeted delivery of drugs and therapeutic genes to tumours and cerebral diseases. She has been awarded the Biochemical Journal Young Investigator Award (2009) and the Tom Gibson Memorial Award (2012) for her research, in addition to the Best Overall Strathclyde Teaching Excellence Award 2013 for her teaching. She sits on the editorial boards for 17 journals.

Close

**Martin J. D'Souza**

Vaccine Nanotechnology Laboratory
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Biography of Martin J. D'Souza

Dr. Martin J. D'Souza obtained his Ph.D. degree (1987) in Pharmaceutical Sciences from the University of Pittsburgh, Pittsburgh, PA, USA. Dr. D'Souza is currently performing numerous roles at Mercer University, Atlanta, GA, USA, i.e. Professor & Director of Graduate Programs in the College of Pharmacy. He is the Director of Mercer Clinical Laboratory, Co-Director of the Center for Drug Delivery Research, and Chair of the Pharmaceutics. He is the co-founder of Drug Delivery Therapeutics. His main fields of specialization include Vaccines, Pharmacokinetics, Bio-pharmaceutics, Bio-technology, etc.

Close

**Biana Godin**

Department of Nanomedicine
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**Khaled F. Greish**

Department of Molecular medicine
Arabian Gulf University
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[Biography](#)

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Biography of Khaled F. Greish

Khaled Greish is Associate Professor of Molecular Medicine, and head of the Nano-research unit, at Princes Al-Jawhara Centre, Arabian Gulf University, Kingdom of Bahrain, and Adjunct Associate Professor of Pharmaceutical Chemistry at University of Utah, USA. He Published > 70 peer reviewed papers, and 10 book chapters in the field of targeted anticancer drug delivery. Controlled Release Society (CRS) awarded him the CRS Postdoctoral Achievement award in 2008 and in 2010; he was elected as the member of the CRC College of Fellows in 2014 at the University of Otago.

Close

**Zhong Gu**

National Engineering Research Center for Biomaterials
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[Biography](#)

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Biography of Zhong Gu

Professor Zhongwei Gu graduated from Peking University in 1981 and served as a senior visiting scholar in the Research Triangle Institute, RTP and the University of Utah, USA, respectively from 1984 to 1986 and 1991 to 1993. He was appointed as a Professor in 1994, and has thrice been the Chief Scientist of the National Basic Research Program of China (the 973 program) since 1999. He is a Fellow of International Union of Societies for Biomaterials Science and Engineering (FBSE). His current research activities focus on the biomedical polymers, nano-biomaterials and drug delivery systems and tissue engineering.

Close

**Jianfeng Guo**

School of Pharmaceutical Sciences
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[Biography](#)



Biography of Jianfeng Guo



Dr. Jianfeng Guo, Ph.D., is a Professor of Nanomedicine at School of Pharmaceutical Sciences, Jilin University, China. He received his PhD in 2011 from University College Cork (UCC), Ireland. He was a Research Fellow at University of Michigan, Ann Arbor, followed by industrial working experience at the Viva Biotech Ltd., Shanghai, as a Project Manager. He then spent three years at UCC as a Senior Research Fellow, prior to joining in Jilin University in 2016. He was awarded the Embark Initiative Postgraduate Scholarship, Chinese Government Award for Outstanding Self-financed Students Abroad. Dr. Jianfeng Guo has published 24 peer-reviewed scientific articles.

Close



Umesh Gupta

Department of Pharmacy
Central University of Rajasthan
Ajmer
(India)

[Biography](#)



Biography of Umesh Gupta



Dr. Umesh Gupta, currently working as Assistant Professor in the Department of Pharmacy, Central University of Rajasthan, India. He did Ph.D. in Pharmaceutical Sciences from Dr. H. S. Gour University, Sagar, India under the mentorship of Prof. NK Jain. He has recently been awarded “DAAD Research Stays for Academics and Scientists” at Leibniz-institut fur Polymerforschung Dresden, Germany. He has the past experience of working as Research Scientist at Ranbaxy Research Laboratories, India and Post-Doctoral Research Associate at South Dakota State University, USA. He joined the Central University of Rajasthan in the year 2013.

Close



Lisbeth Illum

Identity - Pharmaceutical Consultancy
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[Biography](#)



Biography of Lisbeth Illum



Professor Lisbeth Illum was the founder and Managing Director of DanBioSyst UK Ltd a drug delivery technology company, sold successfully to West Pharmaceutical Services and now Archimedes Lab Ltd. She was the CEO of Critical Pharmaceuticals Ltd a drug delivery company. She now works as a consultant to the pharmaceutical industry and exert witness in patent litigations. She was awarded M. Pharm, Ph. D and D.Sc. from the Royal Danish School of Pharmacy in 1972, 1978 and 1988, respectively. Her research expertise is in the area of novel drug delivery systems for difficult drugs, such as hydrophilic and insoluble drugs, peptide and proteins. She has published more than 350 scientific papers, co-edited four books and filed more than 45 patent family applications on novel drug delivery systems, of which a large number of patents have been granted. She has lectured extensively throughout the world at conferences and workshops. She is a Fellow of the AAPS and CRS. She has been on the editorial boards of eleven scientific journals.

Close



Kazunori Kataoka

Department of Materials Engineering
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Xin-Gui Li

College of Environmental Science & Engineering
Tongji University
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[Biography](#)

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Biography of Xin-Gui Li



Dr. Xinn- Guii Lii obtained PhD in Polymer Materials from China Textile University, Shanghai. He is presently serving as Professor of Polymer Materials and Director of Inst. of Mater Chem at Tongji University, Shanghai, China. He has been recognized with many awards and honors such as ACS Membership Award in 2015, Natural Science Prize in 2015 and many other awards. He is also a member of different organizations such as ACS, National Engineering Research Center of Electronic Circuits Base Materials of China, Key Laboratory of Advanced Polymer Materials, Shanghai, China, Educational Ministry of China, and Shanghai Key Laboratory for Advanced Polymer Materials.

Close

Ulrich Lächelt

Department of Pharmacy
Ludwig Maximilian University of Munich



Munich
(Germany)
[Biography](#)



Biography of Ulrich Lächelt



Ulrich Lächelt studied pharmaceuticals at the University of Heidelberg and received a doctoral degree in Pharmaceutical Biology at the LMU Munich in 2014. He worked on multifunctional sequence-defined nucleic acid carriers together with Prof. Ernst Wagner. Since 2017 he continues the research on drug delivery and nanomedicine as junior research group leader and candidate for habilitation. He is an extraordinary member of the Center for NanoScience (CeNS) at the LMU. His research focuses on the intracellular delivery of biomacromolecules, such as nucleic acids, peptides and proteins, the development of drug conjugates and inorganic-organic hybrid nanopharmaceuticals.

Close



Achuthamangalam B. Madhankumar

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Pennsylvania State University
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Tamara Minko
Department of Pharmaceutics
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[Biography](#)



Biography of Tamara Minko



Tamara Minko, Ph.D., is a Distinguished Professor and Chair of the Department of Pharmaceutics at Rutgers University. Her current research interests include nanotechnology; drug delivery; personalized nanomedicine; molecular targeting; nucleic acids delivery; mechanisms of multidrug resistance; bioimaging; preclinical evaluation of new therapeutics; and modulation of cell death mechanisms during hypoxia. Professor Minko is author and coauthor of more than 400 publications. Dr. Minko is an elected Fellow of CRS, AAPS, and AIMBE; recipient of numerous awards. She also is an Executive Editor of *Advanced Drug Delivery Reviews*, Editor of *Pharmaceutical Research*, President-Elect of the Controlled Release Society.

Close



Teresa Musumeci
Department of Drug Science
University of Catania
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Biography of Teresa Musumeci



Teresa Musumeci is an assistant professor and research scientist in the Department of Drug Sciences at the University of Catania, since 2008. Teresa Musumeci received her Pharmacy degree from the University of Catania (Italy) in 2001. She received her PhD in Pharmaceutical Technology from the University of Palermo (Italy) in 2007. She is the author of 30 peer-reviewed papers and 2 book chapters. Her scientific activity is focused on design and characterization of nanocarriers for delivery of drugs.

Close



Caitriona O'Driscoll
School of Pharmacy
University College Cork
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Kamla Pathak
Department of Pharmaceutics
Uttar Pradesh University of Medical Sciences
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[Biography](#)

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Biography of Kamla Pathak



Professor Kamla Pathak, Professor and Head of the Department of Pharmaceutics, Pharmacy College Saifai, U. P. RIMS&R, Saifai, Etawah, India has a teaching and research experience of more than 26 years. She is actively engaged in research on oral controlled /modulated/targeted and topical drug delivery systems. She has over 200 publications in journals of international and national repute, 3 patents, authored book chapters and more than 180 abstracts of the papers presented in scientific forums to her credit. She has supervised Ph.Ds, more than 120 postgraduate theses and has a h-index of 21.

Close

**Qiang Peng**

West China Hospital of Stomatology
Sichuan University
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[Biography](#)

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Biography of Qiang Peng

Dr. Qiang Peng obtained his B.S. degree (2006), M.A. degree (2009), and Ph.D in pharmaceutics (2012) from Sichuan University, China. He joined West China Hospital of Stomatology, Sichuan University as a lecturer in 2012 and promoted as an associate professor in 2014. Dr. Peng once worked in Keele University from 2010 to 2011 and in University of Copenhagen during 2015. His research focuses on nanomaterials-based advanced drug delivery. As a young scientist, he has published more than 20 publications. He won the Sichuan Provincial Award of Outstanding PhD Dissertation in 2014 and the First Prize of Chinese Outstanding Young Investigator Award, IADR-China Division in 2014.

Close

**Stefano Salmaso**

Department of Pharmaceutical and Pharmacological Sciences
University of Padova
Padova
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[Biography](#)

x

Biography of Stefano Salmaso

Stefano Salmaso is associate professor in the Department of Pharmaceutical and Pharmacological Sciences of the University of Padova (Italy), where he teaches Technology of delivery and controlled release of drugs. He obtained his Ph.D. in Pharmaceutical Sciences in 2004 and the Master degree in Chemistry and Pharmaceutical Technology from the University of Padova. He held positions as assistant professor at the University of Padova and associate scientist at Northeastern University - Boston (USA) in 2005 and 2008. He is author of 58 peer-reviewed publications, 3 book chapters, and inventors of 3 international patents. His scientific activity is focused on the development of responsive “smart” nanocarriers for the delivery of drugs and biopharmaceutics.

Close

Helder Santos

Division of Pharmaceutical Technology, Faculty of Pharmacy
University of Helsinki



Helsinki
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[Biography](#)



Biography of Helder Santos



Dr. Santos obtained a doctorate (D.Sc.) in Chemical Engineering from the Helsinki University of Technology, Helsinki, Finland. Currently Dr. Santos is an Adjunct Professor in Pharmaceutical Nanotechnology at the University of Helsinki, Finland. He has published more than 150 scientific publications. Dr. Santos serves as Editor and is in the Editorial Board of several international journals.

Close



Sevda Senel
Department of Pharmaceutical Technology
Ankara University
Ankara
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[Biography](#)



Biography of Sevda Senel



Sevda Şenel is Professor at the School of Pharmacy at Hacettepe University, Ankara Turkey. Numerous international (NATO-CRG, NATO-CLG, British Council, EU-7-SME) and national (TUBITAK, SAN-TEZ) projects led her group to the development of non-invasive systems for drugs and vaccines via various mucosae (buccal, sublingual and nasal) in human and veterinary field. Dr. Şenel and her research group has been awarded a number of prestigious honors including AAPS-PharmSciTech Best Poster Award (2015), Hacettepe University Science Award (2011), The Distinguished Scientist Award - by the Academy of Science of the Turkish Pharmacists Association (2010), CRSIntervet Best Veterinary Paper Award (2005) and the Novartis Pharmaceutical Technology Research Award (2004). Dr. Şenel is the author of more than 150 research publications, which includes original research and book chapters.

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Biography of Amanda K.A. Silva



Amanda K. A. Silva obtained a degree in Pharmacy in 2005 at UFRN, Brazil, and a PhD in Pharmaceutical Technology in 2008 in the domain of gastro-resistant magnetic microcapsules. She obtained a second PhD in Cellular and Molecular Biology in 2010 from the Université d'Evry, France concerning polysaccharides for thermo-controlled cell culture in 3D. In 2013, Amanda obtained a tenured CNRS researcher position at Matter and Complex Systems lab in Paris. She works in physical approaches for regenerative medicine, extracellular vesicle engineering, theranosis and photo-activated therapies. Amanda has published 37 papers and is an inventor in 4 patents.

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Biography of Vladimir P. Torchilin



Vladimir P. Torchilin, Ph.D., D.Sc. is a University Distinguished Professor of Pharmaceutical Sciences and Director, Center for Pharmaceutical Biotechnology and Nanomedicine, Northeastern University, Boston. His interests include drug delivery and targeting, nanomedicine, multifunctional and stimuli-sensitive pharmaceutical nanocarriers, biomedical polymers, experimental cancer therapy. He has published more than 400 original papers, more than 150 reviews and book chapters, wrote and edited 12 books, and holds more than 40 patents. Google Scholar has shown more than 44,000 citations of his papers with an H-index of 96. He is Editor-in-Chief of Current Drug Discovery Technologies, Drug Delivery, and OpenNano, Co-Editor of Current Pharmaceutical Biotechnology and on the Editorial Boards of many other journals. He received more than \$30 M from the governmental and industrial sources in research funding. He has multiple honors and awards and in 2011, Times Higher Education ranked him number 2 among the top world scientists in pharmacology for the period of 2000-2010.

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Biography of Ernst Wagner



Dr. Wagner is Professor of Pharmaceutical Biotechnology at Ludwig-Maximilians-Universität Munich and a member of the Munich Center for Nanoscience. He coordinates 'Biomedical Nanotechnologies' of the Excellence Cluster 'Nanosystems Initiative Munich'. After a Ph.D. in Chemistry from the Technical University of Vienna and a postdoctoral stay at the ETH Zurich, he was the group leader at the IMP Vienna and Director for Cancer Vaccines at Boehringer Ingelheim Austria. Dr. Wagner has authored more than 390 publications with an h-index 70. He has been a board member of the German Society for Gene Therapy, Committee member of ASGCT, and BSA member of the CRS.

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Biography of Roderick Bryan Walker



Professor Walker completed his Ph.D. degree in Biopharmaceutics and Pharmacokinetics at Rhodes University in Grahamstown, South Africa. He is the former Dean and Head of the Faculty of Pharmacy at Rhodes and is currently the Professor of Pharmaceutics and is the current chair of the Academy of Pharmaceutical Sciences in South Africa. Professor Walker has published and presented over 200 scientific outputs and serves on the editorial boards of a number of journals. Professor Walker undertakes research studies in all aspects of drug delivery and product development.

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Biography of Zimei Wu

Zimei Wu is an Associate Professor at the School of Pharmacy, University of Auckland, New Zealand (NZ). She holds a PhD from University of Otago (NZ) and a Masters from China Pharmaceutical University. Her 'liposomes' research has attracted wide collaborations. She received an NZ-China Scientist Exchange



Award from the Royal Society of NZ. She also researches transdermal delivery with successful stories featured on NZ TV3. Zimei also serves on editorial boards of Journal of Liposome Research, and Pharmaceutical Development and Technology and a referee for >20 journals. Zimei was the past President of NZ Local Chapter of Controlled Release Society.

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Biography of Sarita K. Yadav



Dr. Sarita K Yadav obtained her B. Pharm from DIPSAR and earned her M. Pharm and Ph.D. from IIT(BHU), India. Currently, she is working as Assistant Professor at MLN Medical College, Prayagraj. She has qualified GATE 2009 with AIR-32. She had worked for two years as drug analyst in testing of drugs and cosmetics products at UPFSDA, Lucknow. She had received “Young Scientist Award-WF” in 2015 by SPER for her research contributions. She holds lifetime membership of APTI, IPGA, SPER, and PRISAL. She is a member of editorial board of Micro and Nano System (MNS) by Bentham Science, IJBST journal group and peer reviewer in Future Journal of Pharmaceutical Sciences, Saudi Pharmaceutical Journal etc. Currently, she has many research/reviews papers to her credit in high impact journals with total impact factor around 60.

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Biography of Yanjun Zhao



Prof. Zhao is a Full Professor of Pharmaceutics in the School of Pharmaceutical Science and Technology, Health Science Platform, Tianjin University. He obtained the Bachelor (Polymer), Master (Engineering), and PhD (Pharmacy) degree from Dalian University of Technology, Dalian Institute of Chemical Physics (CAS), and King's College London, respectively. His research interests focus on pharmaceutical micelles, stimuli-responsive drug delivery, and ferroptosis antitumor nanomedicine.

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Biography of Goutam Mondal



Dr. Goutam Mondal is an emerging pharmaceutics and drug delivery scientist. He is an expert in the design and synthesis of receptor targeted lipids and polymeric systems, the techniques of animal tissue culture, tumor growth inhibition studies, and pharmacokinetics studies of small molecules. Presently, he is associated with Dr. Ikhlas A Khan's research group under supervision of Dr. Ryan Yates at the National Center for Natural Products Research, University of Mississippi, USA where he is actively involved in pre-clinical and clinical pharmacokinetics and pharmacodynamics of natural products. He has published 21 research articles in high impact peer-reviewed journals.

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Biography of Mariane L. Nogueira



Dr. Mariane Lira Nogueira is a Pharmacist. She obtained Master's degree in Pharmaceutical Sciences, and Ph.D. in Biological Sciences with an emphasis on Biotechnology. She completed an interuniversity exchange doctorate in Pharmacotechnics (2007-2008) at the Faculté de Pharmacie - Université Paris Sud 11 and an internship at the Universidad de Navarra (2008). She did Post-doc from the Université Paris Saclay (2014-2015). She is currently an Associate Professor at the Federal University of Pernambuco, Brazil, a researcher at the Keizo-Asami Immunopathology Laboratory, and leader of Nanotechnology, Biotechnology, and Cell Culture Research Group. Her research fields are mainly focused on the development and characterization of surface-modified nanocarriers for biomedical applications.

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Meysam Omidi

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Biography of Meysam Omidi



Dr. Meysam Omidi is an Assistant Professor of Protein Research Center, Shahid Beheshti University. Dr. Omid's research is focused on application of nanobiomaterials in soft, hard, and interfacial tissue engineering. He is particularly interested to design and fabricate smart nano drug delivery systems for regenerative medicine application. He has (co)authored over 80 research papers in the field of nanoscience and nanotechnology.

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Biography of Aniruddha Roy



Dr. Aniruddha Roy is currently working as an Assistant Professor in the Department of Pharmacy at Birla Institute of Technology and Science (BITS) - Pilani, India. He is a Pharmaceutical Technologist by training. He completed PhD in Immunology from National Institute of Immunology (NII), New Delhi, India. His main area of PhD thesis work

was immunotherapy of cancer. After PhD, he worked at the Indian Institute of Technology, New Delhi, Ontario Institute for Cancer Research at the University of Toronto, Canada, and University of British Columbia, Canada in various capacities. He has more than ten years of research experience. His research is primarily focused on nanomedicine and targeted drug delivery in different diseases.

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Biography of Ismail Ocsoy



Dr. Ismail Ocsoy is a Professor in the faculty of Pharmacy, Erciyes University, Kayseri, Turkey. He completed his MS and Ph.D. in Chemistry from the Department of Chemistry, University of Florida, USA. His research focuses on Nano biotechnology consisting of DNA Aptamer conjugated nanomaterial, cancer therapy models, anti-cancer, antimicrobial agents and Nano bio-sensor for detection of antibiotic resistant bacteria. He has published more than 70 papers in highly reputable and prestigious journals.

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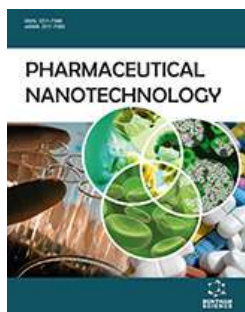




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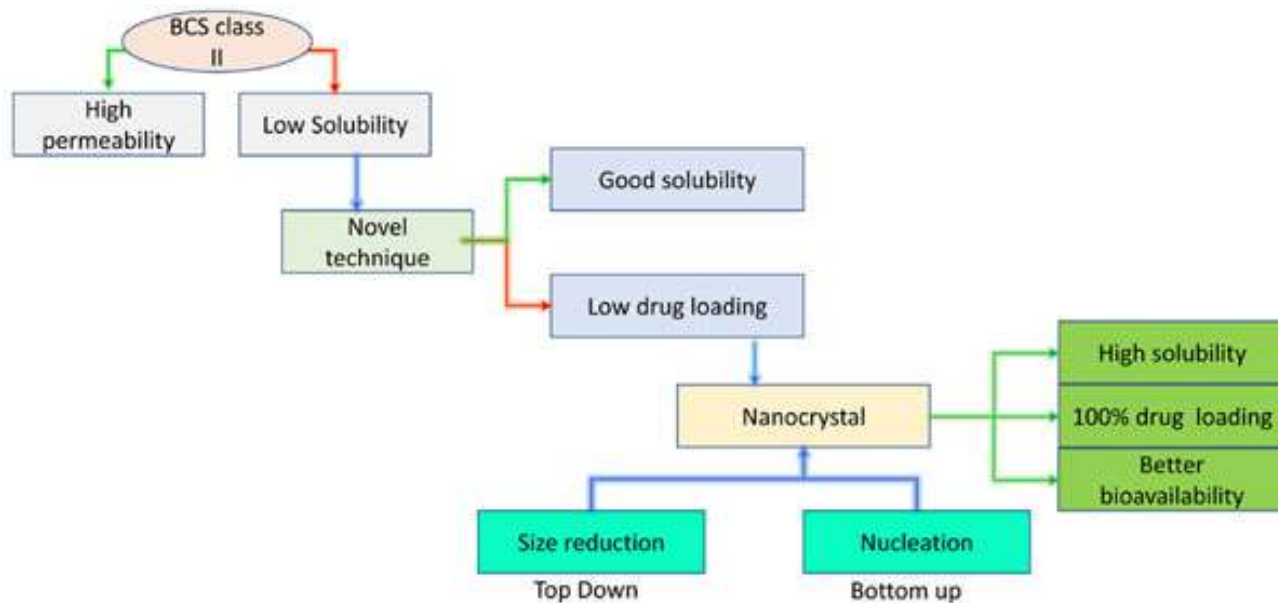
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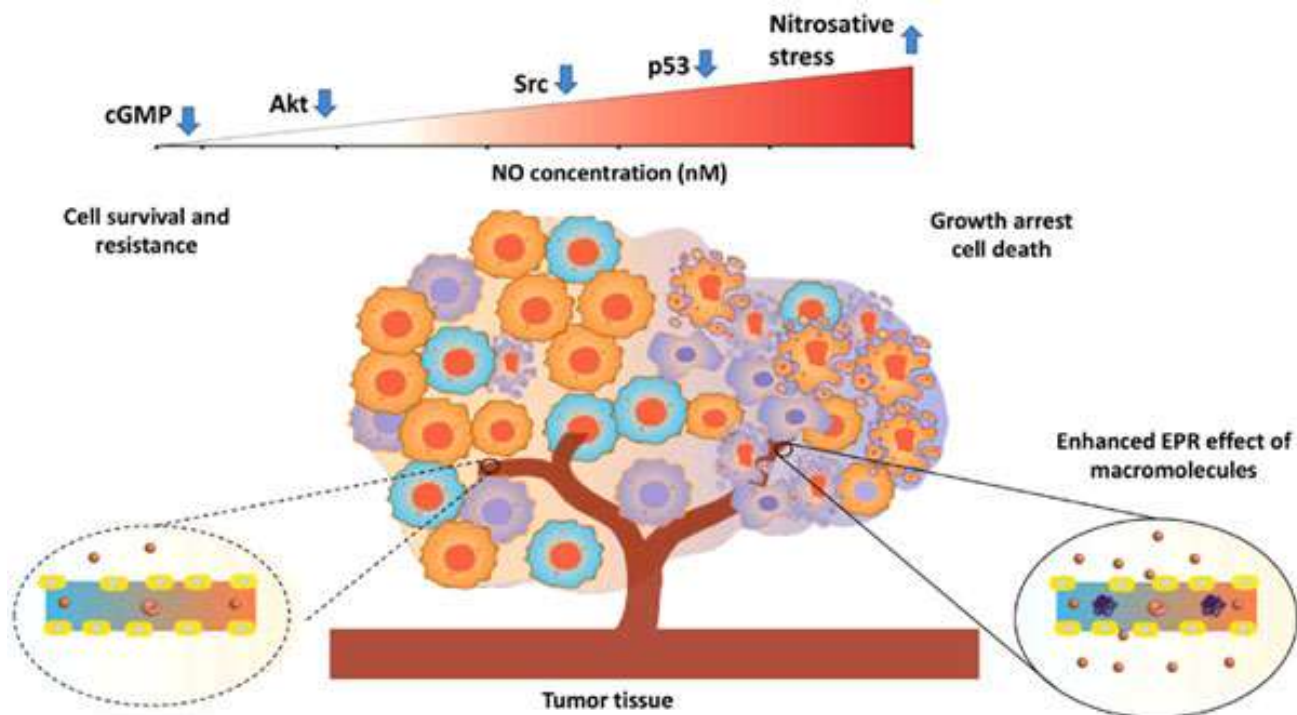
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DOI: 10.2174/2211738507666190717154040 (<http://dx.doi.org/10.2174/2211738507666190717154040>)



- Essential in many metabolic processes
- Important pregnancy supplement

Formulated into liquid dosage form

ADVANTAGES:

- increased drug bioavailability
- better patient compliance
- flexibility in dosing

DISADVANTAGES:

- Folic acid is slightly soluble in water
- Folic acid is not stable; it is pH sensitive

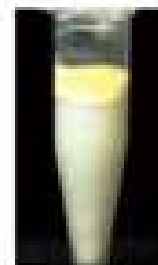
SOLUTION ???

VITAMIN E-BASED FOLIC ACID NANOEMULSION

- Clear and transparent system
- Decrease the degradation rate of folic acid in water medium compared to folic acid in solution



Nanoemulsion



Conventional emulsion

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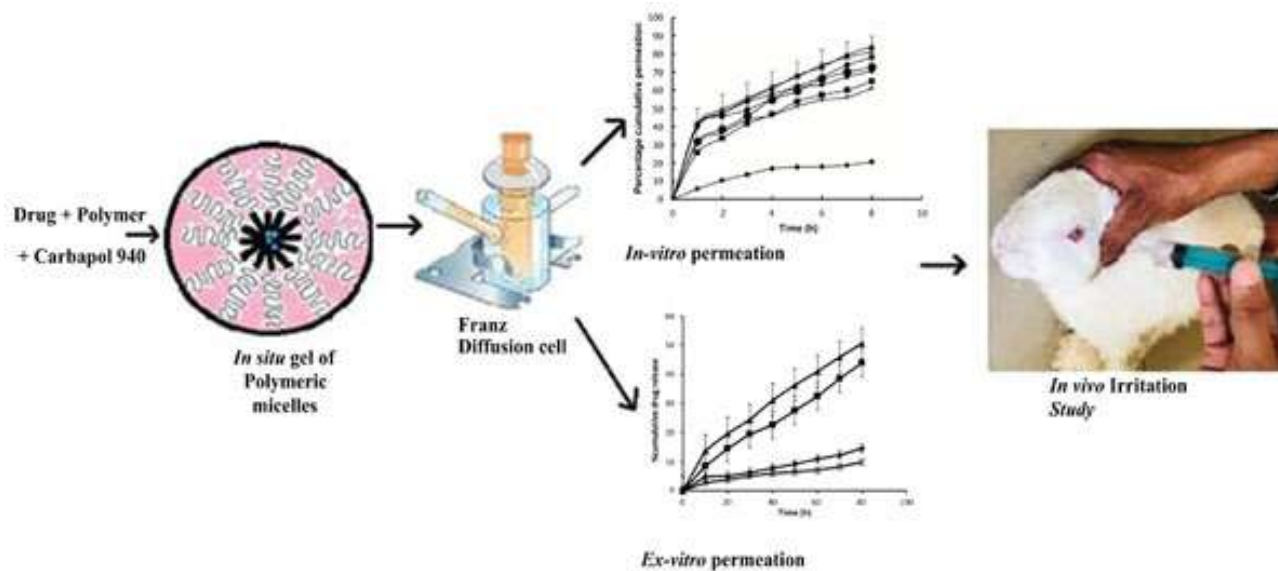
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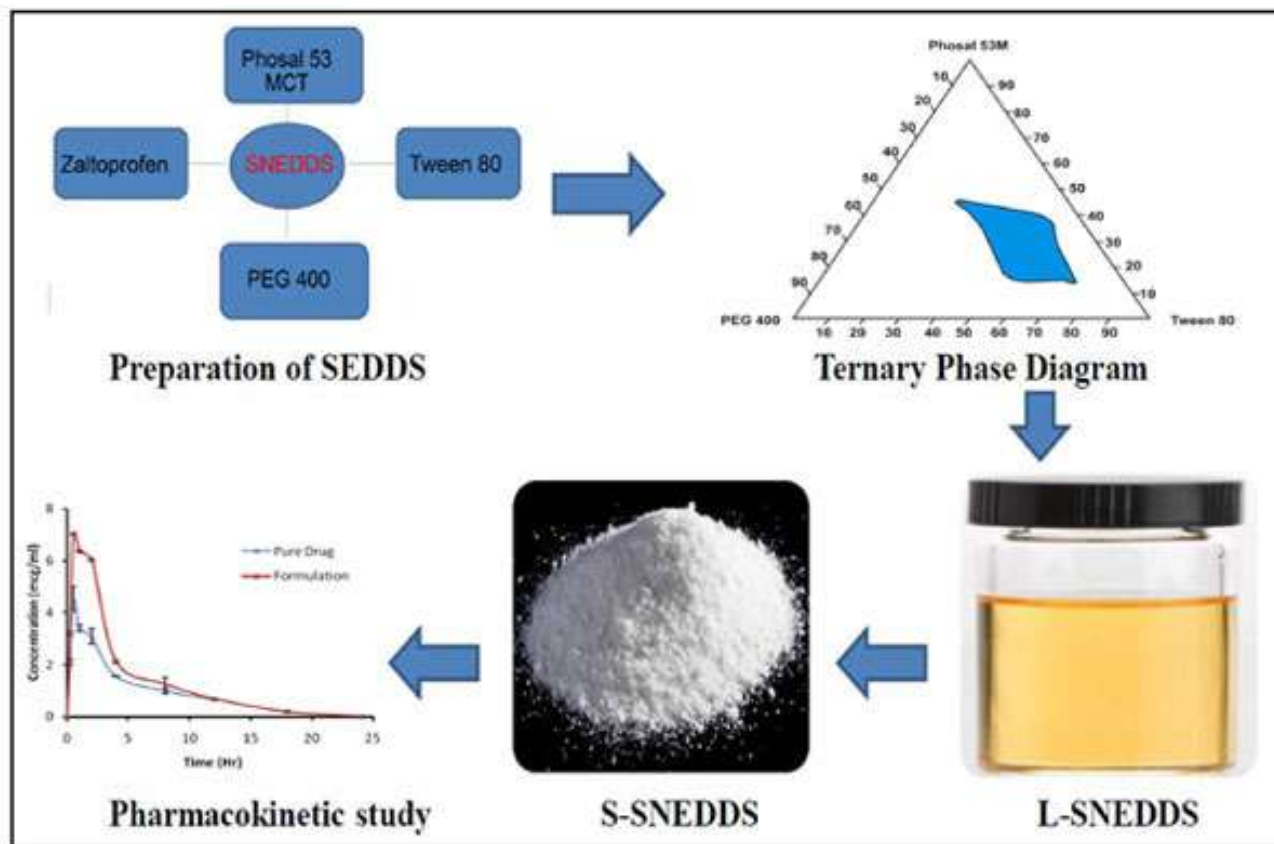
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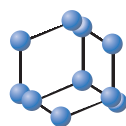
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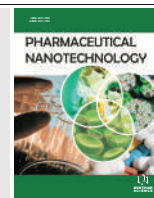
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RESEARCH ARTICLE

BENTHAM
SCIENCE

Vitamin E-based Folic Acid Nanoemulsion: Formulation and Physical Evaluation for Oral Administration



Annis Catur Adi¹, Christanto Christanto², Heni Rachmawati² and Amirah Adlia^{2,*}

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Abstract: Background: Folic acid is essential in many metabolic processes and DNA synthesis. Nevertheless, folic acid is not stable, pH-sensitive, and deteriorated upon light exposure.

Objective: This work was aimed to improve folic acid stability within vitamin E-based nanoemulsion.

Methods: The nanoemulsion was prepared with self-nanoemulsification method by mixing vitamin E oil, Tween 20, and PEG 400. A pseudoternary phase diagram was constructed with aqueous titration to determine the optimum ratio for the mixture. The globule size, pH and entrapment efficiency were included in the nanoemulsion characterizations. In addition, the influence of centrifugation, storage, and pH on physical and chemical stabilities of folic acid nanoemulsion was evaluated.

Results: Optimum formula was obtained from vitamin E, Tween 20, and PEG 400 with the ratio of 1:11:1, and the folic acid amount was 8 mg. The size of folic acid-loaded oil globule was 15.10 ± 1.51 nm, and the nanoemulsion pH was 6.24 ± 0.01 . The nanoemulsion system was able to load the folic acid completely. Folic acid in nanoemulsion was stable after 14 days at room temperature, and it was more stable compared to folic acid in solution. In addition, the physical and chemical characteristics of folic acid in nanoemulsion was not affected by the simulated gastric condition.

Conclusion: Hence, nanoemulsion is a promising strategy to enhance folic acid stability.

Keywords: Folic acid, nanoemulsion, self-nanoemulsification, stability, vitamin E oil, entrapment efficiency.

1. INTRODUCTION

Folic acid has a vital role in the cellular growth and development, mainly in its ionic form. In the body, folate (the anionic form of folic acid) acts as a cofactor for many important cellular reactions including the transfer of single-carbon units, which is required for cell division in the DNA synthesis

[1]. Thus, folate deficiency may cause abnormal cell division due to DNA synthesis interference. One of the first known clinical manifestations of folate deficiency is hypersegmentation of the neutrophils [2].

Supplementation of folic acid has been recommended for pregnant women since 1991 [3]. The recommendation was based on findings that folic acid consumption can prevent neural tube defects, which are among the most common severe congenital malformations [3]. In elderly people, folic acid deficiency has been associated with neuro-

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psychiatric disorders in the absence of anemia, for instance in some depressions and dementias, including Alzheimer's disease [4].

In commercial products, folic acid is often available in combinations with other vitamins. Its most stable storage condition is in aqueous solutions at a pH of 5-8 [5, 6]. Folic acid is well-known to be photolabile, because of its capability in absorbing UV irradiation [1, 7, 8]. The molecular structure of folic acid is divided into three parts: a glutamic acid moiety, a p-aminobenzoic acid moiety, and a pterin moiety [1, 9]. Upon exposure to UV light, folic acid is degraded by cleavage on the methylene bridge into 6-formylpterin and p-aminobenzoyl-L-glutamic acid. Further UV irradiation led to cleavage of p-aminobenzoyl-L-glutamic acid leading to p-aminobenzoic and glutamic or degradation of 6-formylpterin to pterin-6-carboxylic acid [1, 7, 10, 11]. At temperatures lower than 180°C, folic acid is relatively stable because glutamic acid, pterin and p-aminobenzoic are degraded at 180°C [1].

In this research, the stability of folic acid was improved by formulating folic acid in nanoemulsion system. Folic acid was incorporated in the system stabilized by the mixture of surfactant and cosurfactant. Thus, folic acid was expected to be stable in the aqueous dispersion system. Self-nanoemulsification (SNE) or spontaneous method was applied to produce nanoemulsion which can further be incorporated in the liquid dosage form. It is known that oral liquid dosage form offers several advantages, *i.e.* increased drug bioavailability, better patient compliance, and flexibility in dosing especially in situations where dose adjustments in hepatic or renal impaired patients are required [12]. Most importantly, it is ideal for patients who cannot swallow tablets or capsules. Nanoemulsion can be formed spontaneously when there is less required free energy. The presence of globule interfacial stabilization decreases the surface tension, so the required free energy for the nanoemulsion production is very low [13].

2. MATERIALS AND METHODS

2.1. Materials

Folic acid (PT Kimia Farma, Bandung, Indonesia), vitamin E (PT Kimia Farma, Bandung, Indo-

nesia), Montanox 20 DF (Tween 20, PT Megasetia Agung Kimia, Indonesia), polyethylene glycol 400 (PEG 400, Merck, Darmstadt, Germany), sodium carbonate (Merck, Darmstadt, Germany), methanol, acetate buffer pH 5.7, acetonitrile pro analysis (J.T. Baker), hydrochloride acid, sterile aquadest (IKA, Indonesia), deionized water (Bandung Institute of Technology, Indonesia).

2.2. Nanoemulsion Preparation

SNE method was applied in the formulation development, in which vitamin E, Tween 20, and PEG 400 were used as oil phase, surfactant, and cosurfactant, respectively. The oil mixture was produced by mixing vitamin E, Tween 20, and PEG 400 using magnetic stirrer for 2 hours and sonicated for 60 minutes. To produce nanoemulsion, deionized water was added to the oil mixture dropwise (oil phase: aqueous phase = 1:4), and the mixture was stirred gently with a magnetic stirrer until a clear system was obtained. Globule size analysis and visual appearance were used to evaluate the optimized formula.

2.3. Pseudoternary Phase Diagram

A pseudo ternary phase diagram of the nanoemulsion was determined by mixing vitamin E with the mixture of Tween 20 and PEG 400 (11:1). The ratio of the mixture was varied from 1:9 to 9:1. The mixing was carried out by using magnetic stirrer, and deionized water was titrated into the mixture. The visual appearance of the mixture was observed, and the specific ratio resulted in nanoemulsion system was used to generate the diagram.

2.4. Folic Acid-loaded Nanoemulsion

The optimization on the folic acid entrapment in the nanoemulsion system was carried out by varying the amount of folic acid (2, 4, 6, 8, and 10 mg) added into 10 g of oil mixture. The mixing procedure was done by using magnetic stirrer for 2 hours and sonicated for 60 minutes. After that, deionized water was added into the mixture with the oil-water ratio of 1:4, and the mixture was stirred to produce folic acid nanoemulsion system. The evaluations on the obtained nanoemulsion included visual appearance, globule size, and entrapment efficiency.

2.5. Physical Evaluation of Folic Acid-loaded Nanoemulsion

2.5.1. Globule Size and Polydispersity Index

Globule size and polydispersity index were determined with photon correlation spectroscopic method by using particle analyzer (Delsa™ Nano C Particle Analyzer, Beckman Coulter). The sample was analyzed at 25°C.

2.5.1.1. Entrapment Efficiency Determination

The entrapment efficiency of folic acid in the nanoemulsion system was determined with a direct method by comparing the entrapped folic acid in the globule with total folic acid in the system. The entrapped and free folic acid was separated by centrifugation of folic acid nanoemulsion at 13,000 rpm for 20 minutes. The free folic acid precipitated, while the entrapped folic acid was in the supernatant.

The entrapped folic acid was determined by using High-Performance Liquid Chromatography (HPLC, Agilent) with C-18 column (Phenomenex® Luna C₁₈, 5 μm, 100 Å, 250 x 4.6 mm) and UV-visible detector at 365 nm. Sodium acetate buffer (0.1 M, pH 5.7) and acetonitrile were used as mobile phase with the ratio of 94:6 and flow rate of 1 mL/min. The sample was first mixed with methanol (1:1) by using vortex for 30 seconds. After that, 600 μl of 0.01 M sodium carbonate was added into the mixture and mixed with vortex for 60 seconds. Total folic acid was determined by using a similar procedure without prior centrifugation. The entrapment efficiency was calculated using the following equation:

$$\text{Entrapment efficiency} = \left[\frac{\text{Entrapped folic acid}}{\text{Total folic acid}} \right] \times 100\%$$

2.5.2. pH Determination

Nanoemulsion pH was determined by using a calibrated pH meter (Mettler Toledo® S20).

2.6. Stability Test

2.6.1. Centrifugation Test

Folic acid nanoemulsion was centrifuged to evaluate its physical stability. The centrifugation was carried out at 13,000 rpm for 30 min, and the

effect on the visual appearance of nanoemulsion was evaluated. Folic acid formulated in conventional emulsion was used as control.

2.6.2. Stability During Storage

The stability of folic acid nanoemulsion after 14 days at room temperature was analyzed. The observations included globule size, polydispersity index, entrapment efficiency, and pH.

2.6.3. Stability at pH 1.2

The physicochemical alteration of folic acid nanoemulsion in the simulated gastric condition was evaluated *in vitro* by using HCl solution pH 1.2. As a comparison, folic acid in 2 g of oil phase containing vitamin E, Tween 20 and PEG 400, was mixed with 8 mL of HCl solution pH 1.2. Globule size, size distribution, and folic acid content were parameters evaluated in this study.

3. RESULTS AND DISCUSSION

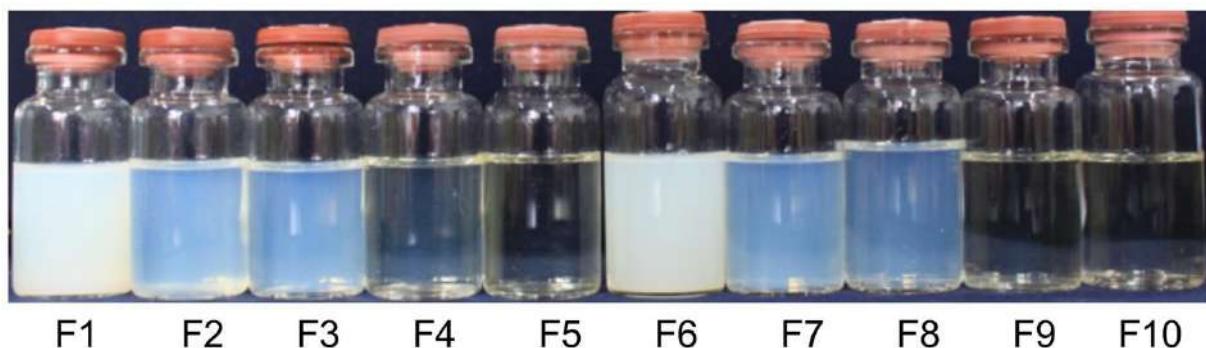
Nanoemulsion formula was developed by varying the ratio of vitamin E oil, Tween 20, and PEG 400. The use of vitamin E as oil phase has beneficial effects for the system. Besides its ability to dissolve folic acid, vitamin E has an antioxidant property that can protect folic acid from oxidation.

Nanoemulsion formation requires high free energy because it has a very large surface area to maintain the globule dispersion. Tween 20 is a surfactant with both hydrophilic and hydrophobic properties, which can form an interfacial layer between water and oil. This layer can decrease the water-oil interfacial tension, which allows the formation of nanoemulsion. A surfactant that can be used to produce oil in water nanoemulsion must have hydrophilic lipophilic balance (HLB) above 10. Tween 20 has HLB of 16.7, so it can be used as a surfactant to produce nanoemulsion. Tween 20 is also a nonionic surfactant with relatively low toxicity [14].

In addition to Tween 20, PEG 400 was used as a cosurfactant to complete the function of Tween 20 in reducing the water-oil interfacial tension. PEG 400 has two hydroxyl and relatively short ethylene groups. These groups are able to penetrate the interfacial area and form a compact layer of surfactant-cosurfactant [15].

Table 1. The characteristics of folic acid-loaded nanoemulsion with various compositions of oil-surfactant-cosurfactant.

Formula	Oil ratio	Surfactant Ratio	Cosurfactant Ratio	Visual Appearance	Globule Size*(nm)	Polydispersity Index
F1	1	7	1	Cloudy	457.30 ± 47.98	0.30 ± 0.02
F2	1	8	1	Slightly cloudy	91.73 ± 13.77	0.30 ± 0.03
F3	1	9	1	Slightly cloudy	35.63 ± 1.53	0.28 ± 0.03
F4	1	10	1	Clear	18.47 ± 5.07	0.27 ± 0.11
F5	1	11	1	Clear	14.20 ± 1.28	0.20 ± 0.13
F6	1	7	2	Cloudy	357.88 ± 112.15	0.31 ± 0.04
F7	1	8	2	Slightly cloudy	90.20 ± 4.33	0.36 ± 0.03
F8	1	9	2	Slightly cloudy	20.17 ± 0.75	0.32 ± 0.01
F9	1	10	2	Clear	16.00 ± 1.38	0.27 ± 0.02
F10	1	11	2	Clear	17.67 ± 4.65	0.31 ± 0.05

**Fig. (1).** Visual appearance of nanoemulsion formula F1 to F10 (left to right).

Among formulas evaluated in this study, formula F5 generated the optimum characteristic of nanoemulsion prototype with oil, surfactant, and cosurfactant with the ratio of 1:11:1 (Table 1) (Fig 1). This composition produced a clear and transparent appearance of nanoemulsion with the smallest globule size of 14.20 ± 1.28 nm and narrow size distribution. The high concentration of surfactant was required to generate spontaneous nanoemulsion with SNE method. This is due to the structure of vitamin E that consists of chromanol ring and long alkyl side chain, causing the hydrophobic property of vitamin E. Oil with long hydrocarbon chain is relatively harder to be emulsified compared to oil with medium or short chain [16, 17].

Based on the optimization result, surfactant-cosurfactant ratio (11:1) was chosen as a component in generating the diagram (Fig. 2). Mo-

nophase area indicates the nanoemulsion formation, in which the obtained system is clear and transparent [18].

As shown in Fig. (2), nanoemulsion was only formed in the specific condition of oil phase, surfactant-cosurfactant and water. In this specific condition, the required free energy to generate spontaneous nanoemulsification is lower [19, 20]. In addition, vitamin E concentration was considered low with a large area of Tween 20-PEG 400 (Fig. 2).

The specific ratio component of nanoemulsion was used to optimize the added amount of folic acid in the system. Different amount of folic acid was added into the mixture of vitamin, Tween 20, and PEG 400 (1:11:1).

Globule size and size distribution are important characteristics in the nanoemulsion system, which

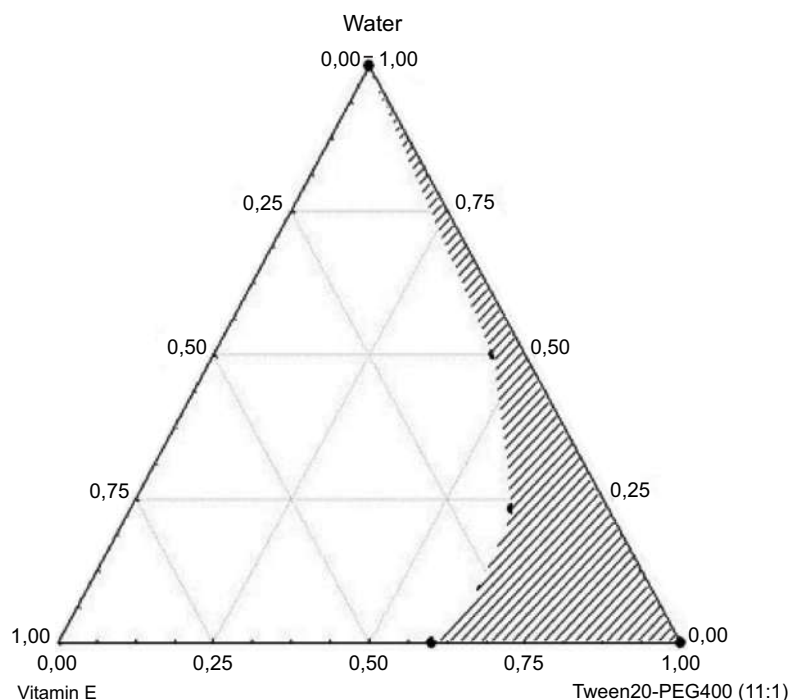


Fig. (2). Pseudoternary diagram of nanoemulsion. The shaded area showed the composition forming nanoemulsion.

Table 2. Globule size and polydispersity index of folic acid nanoemulsion.

Formula	Folic Acid in 10 g Oil Phase (mg)	Visual Appearance	Globule Size (nm)	Polydispersity Index
A	2	Clear	14.17 ± 0.40	0.21 ± 0.07
B	4	Clear	14.70 ± 1.78	0.20 ± 0.08
C	6	Clear	14.93 ± 2.52	0.13 ± 0.06
D	8	Clear	15.10 ± 1.51	0.31 ± 0.06
E	10	Slightly cloudy	118.10 ± 3.29	0.34 ± 0.01

determine the *in vivo* drug distribution, toxicity, and controlled release capability. On top of that, globule size and size distribution influence drug entrapment, drug release profile, nanoemulsion stability [21]. Particle size analysis of folic acid nanoemulsion after mixing oil phase with deionized water is shown in Table 2.

As given in Table 2, the globule size increased as the amount of folic acid increased. Clear nanoemulsion system was obtained from formula A, B, C, D with folic acid content ranging from 2 to 8 mg (Fig. 3). When 10 mg of folic acid was incorporated, the globule size increased significantly to 118.10 nm, and the system was slightly cloudy. This can be explained from the limited solubility of folic acid in the oil phase. Drug solu-

bility in oil determines its entrapment in the nanoemulsion system and the characteristics of the nanoemulsion, especially particle size [22].

Polydispersity index indicates the homogeneity of nanoemulsion globule size. The homogenous system has a polydispersity index close to 0 [23]. Formula A to E had a polydispersity index from 0.13 to 0.34, which indicated homogenous size distribution (Table 2).

The entrapment efficiency of folic acid in the nanoemulsion system was determined with the direct method, in which entrapped folic acid was measured and compared to total folic acid in the dosage form. To reach the highest entrapment efficiency, the drug must interact with the carrier system and not the medium [24]. Thus, it has to be

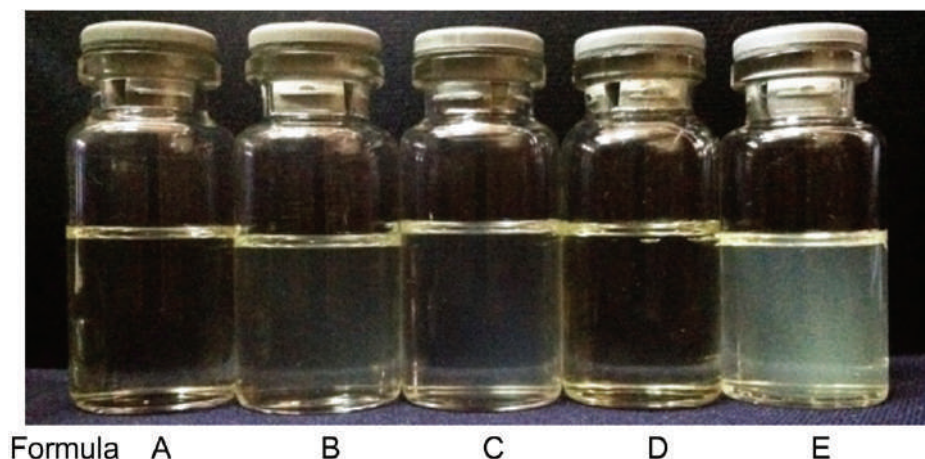


Fig. (3). Visual appearance of folic acid nanoemulsion formula A, B, C, D, and E, containing 2, 4, 6, 8, and 10 mg folic acid respectively (left to right).

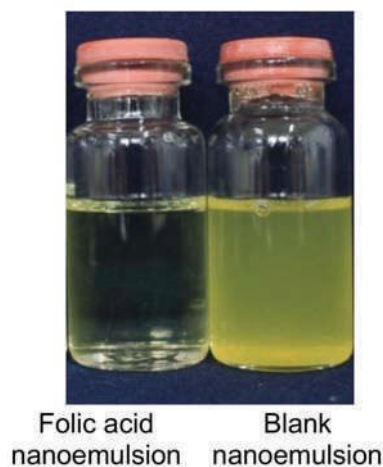


Fig. (4). Visual appearance of folic acid nanoemulsion (left) and blank nanoemulsion with the addition of folic acid (right).

proven that folic acid is entrapped in the nanoemulsion globule and not dissolved in the water.

Fig. (4) shows the comparison of folic acid in the nanoemulsion (entrapped in oil globules) and freely dispersed in the aqueous medium of blank nanoemulsion systems. As seen, folic acid-loaded nanoemulsion has clear and transparent appearance (left) as compared to blank nanoemulsion added with folic acid (right). This proves that additional folic acid in the external medium was not entrapped in the oil globule. On the contrary, the clear appearance of folic acid nanoemulsion indicates entrapped folic acid in the oil globules. If the system is centrifuged, free folic acid will precipitate but entrapped folic acid will stay in the oil globules.

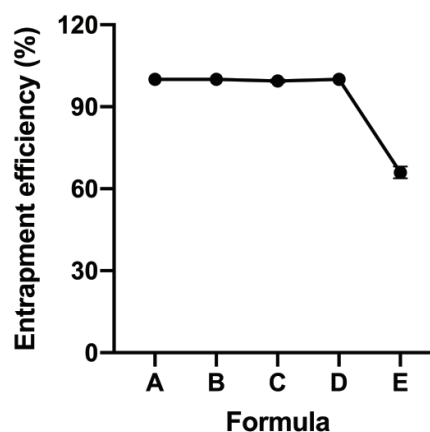


Fig. (5). Influence of folic acid amount on the entrapment efficiency of folic acid in nanoemulsion. Formula A, B, C, D, and E used 2, 4, 6, 8, and 10 mg of folic acid, respectively.

The influence of incorporated folic acid on entrapment efficiency is shown in Fig. (5). The entrapment efficiency of folic acid in the nanoemulsion system with 2 to 8 mg of folic acid was almost 100%. However, it decreased significantly to 66% when 10 mg of folic acid was incorporated. The physicochemical properties and interaction of folic acid with other components in the system might be an explanation. The limited solubility of folic acid in the oil phase causes the available amount of vitamin E was not able to dissolve the incorporated folic acid. Above its maximum capacity, the oil globules in the nanoemulsion system cannot entrap all incorporated folic acid. So, folic acid was only dispersed outside the globules. Entrapment efficiency will decrease when the amount of incorporated drug is above the maximum capacity of the nanoemulsion system.

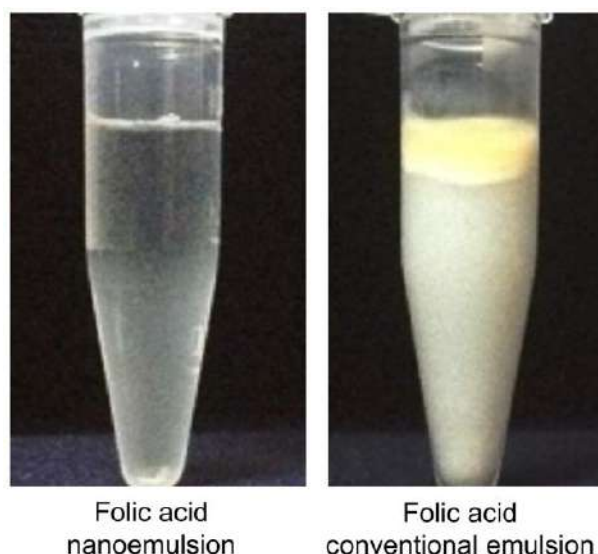


Fig. (6). The physical appearance of folic acid nanoemulsion (left) and conventional emulsion (right) after high speed centrifugation.

Based on the results given in Table 2 and Fig. (5), formula D with 8 mg of folic acid incorporated into 10 g of the oil phase was chosen to be further evaluated. Formula D showed clear and transparent nanoemulsion with particle size < 50 nm, homogeneous size distribution, entrapment efficiency of 100%, and pH of 6.24 ± 0.01 . The pH of the system is critical for the chemical stability of folic acid. In general, folic acid is stable in a medium with pH 5 to 8 [5]. Thus, formula D is in the stable pH range of folic acid.

To predict the physical stability of nanoemulsion, the system was challenged by high-speed centrifugation. According to Stokes' Law, nanoemulsion centrifugation can increase the globule migration rate towards the superficial layer of the nanoemulsion system. As a consequence, there is an increased chance of globule aggregation, which can destroy the surfactant monolayer and form coagulation [25]. The resistance of the nanoemulsion against high-speed centrifugation is shown in Fig. (6). On the contrary, folic acid in the conventional emulsion system showed separation into two phases. As nanoemulsion used surfactant and cosurfactant in a relatively higher amount compared to the conventional emulsion, thus the globules in nanoemulsion are more stable. The presence of cosurfactant optimized the function of surfactant to protect the globules from aggregation.

Fig. (7) shows the stability profile of folic acid nanoemulsion after 14 days of storage. As seen,

the nanoemulsion stayed in the range of 15.0-16.0 nm with a polydispersity index of 0.16-0.31. Furthermore, the system pH was in the range of 5.9-6.4 with the entrapment efficiency of folic acid in the range of 92-100%. There was no significant change of globule size as well as the entrapment efficiency after 14 days of storage at room temperature. This indicated that the system maintained the medium pH, which created a stable condition for folic acid.

To confirm the stability data as presented in Fig. (7), the monitoring of folic acid content was also performed during the stability study. For this purpose, the amount of folic acid in nanoemulsion was determined after 14 days of storage. Folic acid in sodium carbonate solution was used as control.

While folic acid content in nanoemulsion was decreased to 86% after 14 days of storage, folic acid content in sodium carbonate solution decreased to 31% (Fig. 8). It means that folic acid in nanoemulsion was 2.7 times significantly higher compared to folic acid in sodium carbonate solution after 14 days of storage ($p < 0.05$). This indicates that folic acid in nanoemulsion has better stability during storage.

In the nanoemulsion system, folic acid is entrapped in the oil globules. The system stabilization was formed by surfactant and cosurfactant on the interface of globules, which protected folic acid from medium and external factors. The use of

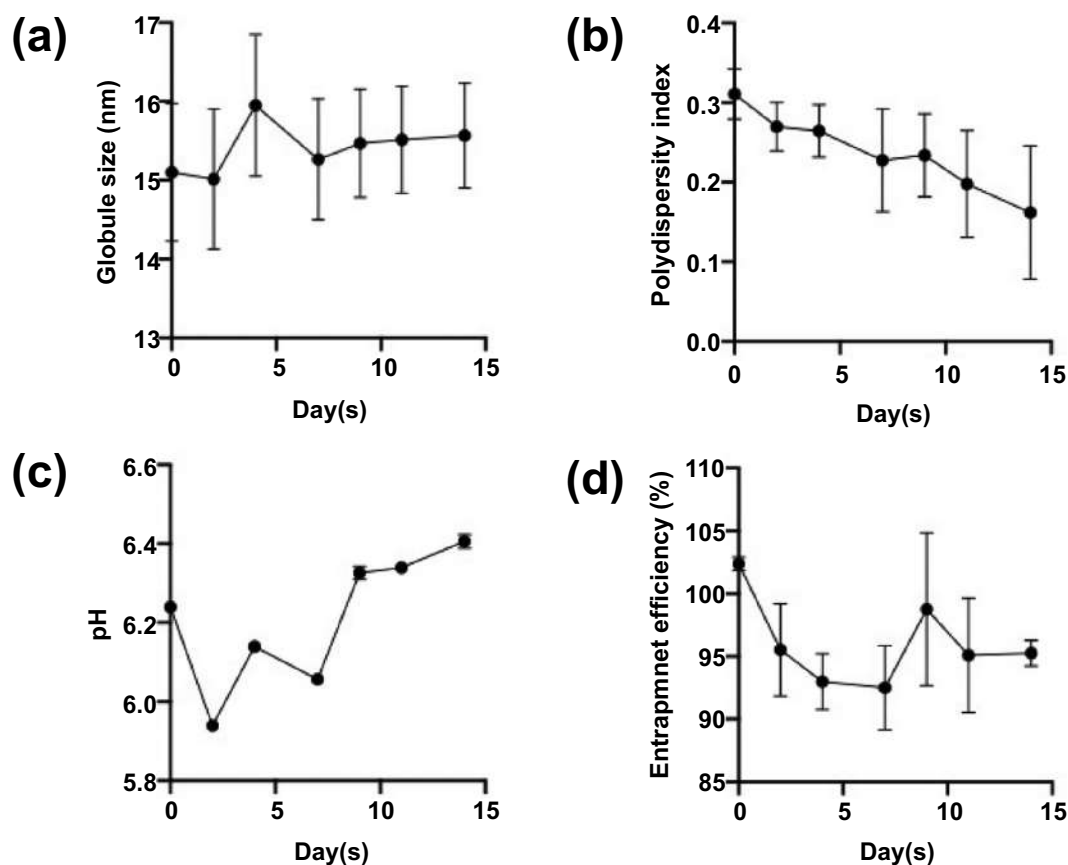


Fig. (7). Folic acid nanoemulsion stability at room temperature after 14 days, which included globule size (a), polydispersity index (b), pH (c), and entrapment efficiency (d).

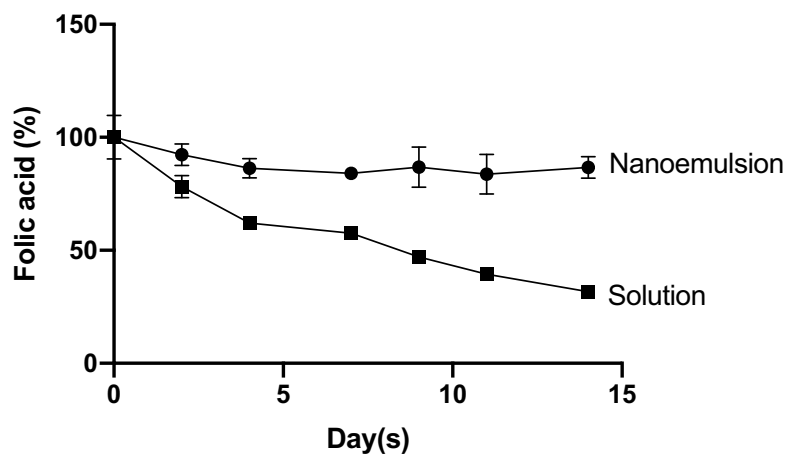


Fig. (8). Influence of storage on the content of folic acid in nanoemulsion (●) and solution (■) at room temperature.

Table 3. Influence of HCl pH 1.2 on physical and chemical properties of folic acid nanoemulsion.

External Phase	Globule Size (nm)	Polydispersity Index	Folic Acid Content (ppm)
Deionized water	15.10 ± 1.51	0.31 ± 0.05	123.11 ± 1.70
HCl pH 1.2	17.03 ± 3.31	0.30 ± 0.13	118.21 ± 8.30

vitamin E as the oil phase also acts as an antioxidant that can protect folic acid from oxidation.

In addition to the data shown in Fig. (8), the stability test was also done in HCl pH 1.2, a simulated gastric acid fluid. As described in Table 3, there was no significant difference of globule size, polydispersity index, and folic acid content in the nanoemulsion system with deionized water and HCl pH 1.2 as an external medium.

4. CURRENT AND FUTURE DEVELOPMENTS

Folic acid is one of the most essential supplements that has been recommended for pregnant women since 1991. However, it is known that folic acid is easily degraded and very sensitive to UV light, heat, and oxygen. Folic acid is commercially available alone or in combinations with other vitamins as solid and liquid dosage forms. Although the formula development of oral liquid dosage form is more challenging, it is more preferable in a certain condition such as dose adjustment for hepatic or renal impaired patients. In addition, liquid dosage form has higher bioavailability than solid dosage form. Nanoemulsion system offers improved stability because it has high kinetic stability and can protect folic acid from extreme conditions. In addition, the nanoemulsion system improved the bioavailability of several compounds. One of them was curcumin, which was developed in our laboratory. Our current study showed that folic acid nanoemulsion is physically and chemically more stable than conventional emulsion and solution. In the future, an accelerated stability test will be done to prove that our formula is stable in longer-term for commercial purposes.

CONCLUSION

The optimum formula for folic acid in this study was obtained using vitamin E, Tween 20, and PEG 400 with the ratio 1:11:1, and 8 mg of folic acid per 10 g of oil phase mixture. This formula generated clear and transparent nanoemulsion with globule size of 15.10 ± 1.51 nm, polydispersity index of 0.31 ± 0.06 , pH of 6.24 ± 0.01 and entrapment efficiency of 100%. Folic acid nanoemulsion was stable after centrifugation, stored in room temperature for 14 days, and it was

physically and chemically stable in simulated gastric acid condition pH 1.2. Nanoemulsion system has been proven to increase folic acid stability and decrease the degradation rate of folic acid in water medium significantly compared to folic acid in solution.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author, [Dr. Amirah Adlia], upon request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

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