(E)-3-[3-(4-Morpholinophenyl)acryloyl]-2H-chromen2-one

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Short Note

(*E*)-3-[3-(4-Morpholinophenyl)acryloyl]-2*H*-chromen-2-one

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Abstract: A new compound (*E*)-3-[3-(4-morpholinophenyl)acryloyl]-2*H*-chromen-2-one, a coumarin based chalcone derivative, has been successfully synthesized employing a molecular hybridization method through the reaction between 3-acetylcoumarin and 4-morpholinobenzaldehyde using a Claisen–Schmidt reaction using *p*TSA as a catalyst. The structure of the title compound was established using spectroscopic data FTIR, HRESI-MS, ^{1}H- and ^{13}C-NMR. The anticancer activity against breast cancer cells line T47D and cervix cancer cells line HeLa was determined using an MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay.

Keywords: molecular hybridization; coumarin-chalcone; anticancer

1. Introduction

Combining different pharmacophoric moieties from different bioactive compounds to generate a new hybrid compound showing better affinity and efficacy, with fewer undesired side effects, than the parent compounds becomes a new concept in drug design and development, which is known as molecular hybridization [1]. An example of such hybridization is a compound constructed from coumarin and chalcones. Coumarins are secondary metabolites possessing a benzopyran ring that can also be found as synthetic products and are already known for their various pharmacological activities such as antimycobacterial [2], inhibitor of HIV-1 [3], inhibitor of platelet aggregation, and to smooth muscle contraction in vitro [4]. Meanwhile, chalcones (1,3-diaryl-2-propen-1-ones) belong to the group of flavonoids, which can be obtained from a plant origin and from synthesis. The bioactivities of chalcones are well known, such as cytotoxic agents against tumor cells [5], along with being antimalarial [6,7], antibacterial [8,9], and anticancer [10]. The pharmacological activities of coumarin–chalcone derivatives containing urea moiety as an anticancer agent has also been reported [11].

Based on this consideration, we designed a coumarin–chalcone hybrid compound containing morpholino-phenyl moiety and synthesized it successfully through a Claisen–Schmidt reaction. Furthermore, the prepared compound was evaluated in relation to its anticancer activity against breast cancer cell line T47D and cervix cancer cell line HeLa using an MTT assay.

2. Results and Dicussion

The title compound **5** was prepared using a two-step reaction. The first step was the synthesis of 3-acetylcoumarin **3** from the reaction of 2-hydroxybenzaldehyde **1** with ethyl acetoacetate **2**. Compounds of the ketocoumarin type are usually synthesized from salicylaldehyde using a cyclic

secondary amine piperidine [12]. However, in our experiment, we used triethyl amine, a tertiary amine, as a catalyst.

Compound **3** was then reacted with 4-morpholinobenzaldehyde **4** to furnish the target molecule **5** employing a Claisen–Schmidt reaction. First, we conducted the synthesis of compound **5** using a solution of KOH 40% as a catalyst as is generally used for aldol condensation. However, we did not get the desired product. We assumed that KOH solution hydrolyzed the 3-acetylcoumarin. Then we decided to use *p*-toluenesulfonic acid (*p*TSA) as a catalyst, and the reaction proceeded to give the desired product. The reaction process is displayed in Figure 1.

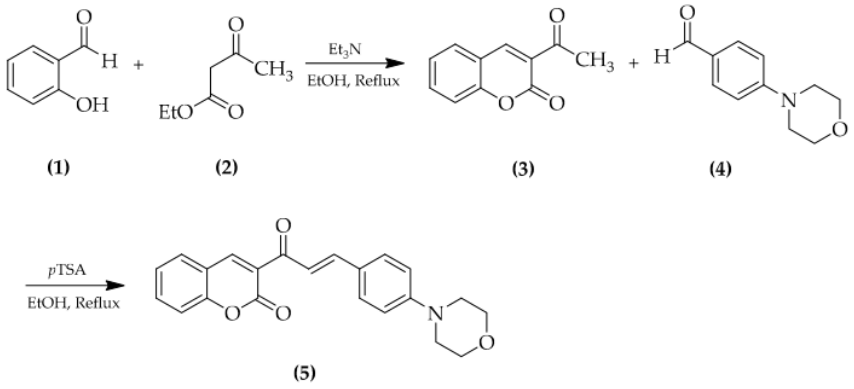


Figure 1. Synthesis pathway of the target molecule.

(*E*)-3-[3-(4-Morpholinophenyl)acryloyl]-2*H*-chromen-2-one: red needle crystal (0.88 g, 24%), R_f 0.58 (*n*-hexane:ethyl acetate 3:2), HRMS(ESI) $[M + Na]^+$ for $C_{22}H_{19}NO_4$ m/z = 384.1212 (calculated) and 384.1215 (observed); IR (DRS, KBr, cm^{-1}): 3094 (C–H aromatic), 2855 (C–H aliphatic), 1724 (C=O ketone), 1605 (C=C conjugated), 1572 (C=C aromatic), 1171 (C–O ether). ^{1}H-NMR (400 MHz, $CDCl_3$) δ_H 8.57 (s, 1H), 7.85 (d, J = 15.6 Hz, 1H), 7.79 (d, J = 15.6 Hz, 1H), 7.66 (m, 2H), 7.61 (d, J = 8.9 Hz, 2H), 7.39 (d, J = 8.3 Hz, 1H), 7.34 (t, J = 7.6 Hz, 1H), 6.89 (d, J = 8.9 Hz, 2H), 3.86 (t, J = 5.3 Hz, 4H), 3.28 (t, J = 5.3 Hz, 4H). ^{13}C-NMR (101 MHz, $CDCl_3$) δ_C 186.3 (C), 159.6 (C), 155.3 (C), 153.0 (C), 147.8 (CH), 145.6 (CH), 134.1 (CH), 130.9 (CH), 130.1 (CH), 125.9 (C), 125.8 (C), 125.0 (CH), 120.6 (CH), 118.8 (C), 116.8 (CH), 114.6 (CH), 66.7 (CH_2), 48.0 (CH_2).

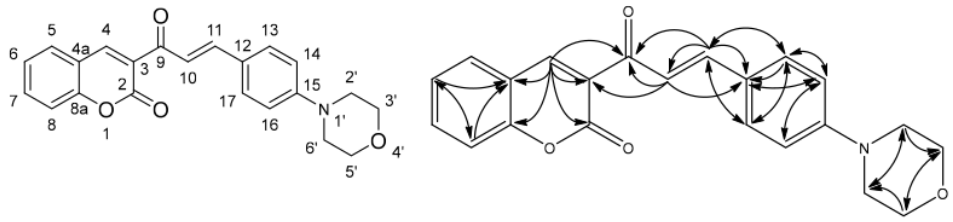
This paper discusses only the title compound **5** because compound **3** is already known. The spectroscopy data of compound **3** are presented in Supplementary Materials (Figures S1–S4). The HRMS spectrum of the title compound showed a positive molecular ion of $[M + Na]^+$ at m/z = 384.1215, suitable for a molecular formula of $C_{22}H_{19}NO_4$, which corresponded to 14 equivalent double bonds of (Supplementary Materials Figure S6). Analysis of the FTIR spectrum showed a stretching vibration band of a C–H aromatic bond at ν_{max} (cm^{-1}) 3094, and followed subsequently with a stretching vibration band of a C–H aliphatic bond at 2855, vibration band of ketone group at 1724, vibration band of conjugated alkene at 1605, vibration band of C–C aromatic bond at 1572, and stretching vibration band of C–O ether group at 1171 cm^{-1} (Supplementary Materials Figure S5).

From the ^{1}H-NMR spectrum, the existence of a coumarin fragment substituted at position 3 was shown via four signals, those were three signals of aromatic protons at 7.66, 7.39, and 7.34 ppm and a signal of a conjugated olefinic proton at 8.57 ppm. The presence of a chalcone scaffold with *E* geometry was proved via two coupled (J = 15.6 Hz) olefinic proton signals at 7.85 and 7.79 ppm. Furthermore, a para disubstituted benzene fragment was shown via two coupled (J = 8.9 Hz) aromatic signals at 7.61 ppm and 6.89 ppm. The existence of a morpholine fragment was proved by two triplet signals at 3.86 and 3.28 ppm with the integration of four for each signal representing two symmetrical ethylene fragment (Supplementary Materials Figure S7a,b). The spectrum of ^{13}C-NMR

exhibited 18 signals indicating that the molecular structure consisted of 8 symmetrical carbon atoms (Supplementary Materials Figure S8), whereas the correlation of the proton atoms with carbon atoms were assigned using the 2-D NMR experiment of Heteronuclear Multiple Bond Correlation (HMBC) (Supplementary Materials Figure S10) and Heteronuclear Multiple-Quantum Correlation (HMQC) (Supplementary Materials Figure S9) as shown in Table 1 and Figure 2 below.

Table 1. NMR data of the title compound in $CDCl_3$.

No. Atom	δ_H (ppm) (mult, *J* Hz)	δ_C (ppm)	HMBC
2		159.6	
3		125.8	
4	8.57 (s, 1H)	147.8	C-2, C-3, C-4a, C-5, C-8a, C-9
4a		118.8	
5	7.66 (m, 2H) overlapped with H-7	130.1	
6	7.34 (t, *J* = 7.6 Hz, 1H)	125.0	C-4a, C-8
7	7.66 (m, 2H) overlapped with H-5	134.1	
8	7.39 (d, *J* = 8.3 Hz, 1H)	116.8	C-4a, C-6
8a		155.3	
9		186.3	
10	7.79 (d, *J* = 15.6 Hz, 1H)	120.6	C-3, C-9, C-12
11	7.85 (d, *J* = 15.6 Hz, 1H)	145.6	C-9, C-10, C-12, C-13, C-17
12		125.9	
13, 17	7.61 (d, *J* = 8.9 Hz, 2H)	130.9	C-11, C-13, C-14, C-15, C-16, C-17
14, 16	6.89 (d, *J* = 8.9 Hz, 2H)	114.6	C-12, C-13, C-14, C-16, C-17
2′, 6′	3.86 (t, *J* = 5.3 Hz, 4H)	48.0	C-2′, C-3′, C-5′, C-6′
3′, 5′	3.28 (t, *J* = 5.3 Hz, 4H)	66.7	C-2′, C-3′, C-5′, C-6′



(**a**) (**b**)

Figure 2. (**a**) Structure numbering, and (**b**) HMBC correlation of the title compound.

The anticancer activity of the prepared compound against cervix cancer cells line HeLa and breast cancer cells line T47D was determined using an MTT assay, and revealed an IC_{50} of 0.90 μM for breast cancer cells line T47D and of 2.32 μM for cervix cancer cell HeLa, and it can be considered as not active as an anticancer compound (Supplementary Materials Table S1).

3. Materials and Methods

3.1. General

All reagents and solvents were provided from the commercial sources (E.Merck, Darmstadt, Germany or Sigma Aldrich, St. Louis, MO, USA) and used without prior purification. The reaction progress was monitored via a Thin Layer Chromatography (TLC) experiment using an aluminium silica gel plate GF_{254} (0.25 mm) employing different solvents. The TLC spot was detected using UV light (λ = 254 nm). The FTIR spectrum was recorded on a IRTracer100 spectrometer (Shimadzu, Kyoto, Japan) using a diffuse reflectance method), whereas the mass spectrum was recorded on a HRESIMS QTOF micrOTOF-Q II Bruker Compass (Billerica, MA, USA). The NMR spectrum (^{1}H-, and ^{13}C-APT)

was recorded on a JEOL JNM-ECS400 spectrometer (at 400 and 100 MHz) (JEOL Ltd., Tokyo, Japan) with $CDCl_3$ as the solvent and internal standard.

3.2. Synthesis of 3-Acetylcoumarin **3**

The mixture of 0.65 g (5 mmol) ethyl acetoacetate, 0.61 g (5 mmol) salicylaldehyde, and three drops of triethylamine in 10 mL ethanol was refluxed in a round bottom flask for 8 h. The reaction progress was monitored via TLC and was stopped when it completed. The precipitate was filtered off and recrystallized using ethanol.

3.3. Synthesis of the Title Compound **5**

The mixture of 3-acetylcoumarin **3** (0.1881 g; 1 mmol), 4-morpholinobenzaldehyde **4** (1.1911 g; 1 mmol), and *p*TSA (0.034 g; 0.2 mmol) in 10 mL ethanol was refluxed for 6 h. The reaction progress was monitored with TLC and stopped at completion. The precipitate was then filtered off and subjected to column chromatography for purification using *n*-hexane:ethyl acetate (3:2) as a mobile phase to furnish the pure title compound.

3.4. Evaluation of Anticancer Activity

The evaluation of the anticancer activity of the title compound was conducted using an MTT assay following the protocol of Tabata et al. [13]. The cancer cells were seeded in a 96-well plate at a density of 1×10^4 cells/well with a phenol red-free RPMI (Roswell Park Memorial Institute medium) 1640 medium (containing 10% FBS (fetal bovine serum)) and maintained for 24 h. Subsequently, the tested compound (various concentrations) was applied for 24 h. After addition of 0.5% MTT solution, the incubation was continued for a further 4 h at 37 °C/5% CO_2. The stop solution (0.04 N HCl in isopropanol) was added to the culture medium to each well. Then, the absorbance at 570 nm (peak) and 630 nm (bottom) was measured using an ELISA (Enzyme-Linked Immunosorbent Assay) reader. It was conducted in triplicate. Doxorubicin was used as a positive control. The value of IC_{50} was determined using a probit analysis (SPSS 17, IBM Analytics, New York, NY, USA).

4. Conclusions

We have successfully synthesized a new compound (*E*)-3-[3-(4-morpholinophenyl)acryloyl]-2*H*-chromen-2-one through a Claisen–Schmidt reaction using a molecular hybridization method between 3-acetylcoumarin, 4-morpholinobenzaldehyde, and *p*TSA as a catalyst.

Supplementary Materials: The following are available online, FTIR, HRESI-MS, ^{1}H-NMR, ^{13}C-NMR (APT) spectra, and anticancer evaluation of the title compound are reported in the Supplementary Materials as Figures S1–S10 and Table S1.

Author Contributions: H.S. brought the idea, managed the research, and wrote the paper. H.D.H. performed the synthesis, K.U.H. and A.N.K. analyzed the whole spectra, while M.K. conducted the anticancer test. All the authors have read the draft.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Viegas-Junior, C.; Danuello, A.; da Silva Bolzani, V.; Barreiro, E.J.; Fraga, C.A.M. Molecular hybridization: A useful tool in the Design of New Drug Prototypes. *Curr. Med. Chem.* **2007**, *14*, 1829–1852. [CrossRef] [PubMed]

2. Appendino, G.; Mercalli, E.; Fuzzati, N.; Arnoldi, L.; Stavri, M.; Gibbons, S.; Ballero, M.; Maxia, A. Antimycobacterial Coumarins from the Sardinian Giant Fennel (*Ferula communis*). *J. Nat. Prod.* **2004**, *67*, 2108–2110. [CrossRef] [PubMed]
3. Ma, T.; Liu, L.; Xue, H.; Li, L.; Han, C.; Wang, L.; Chen, Z.; Liu, G. Chemical Library and Structure-Activity Relationships of 11-Demethyl-12 oxo Calanolide A Analogues as Anti-HIV-1 Agents. *J. Med. Chem.* **2008**, *51*, 1432–1446. [CrossRef] [PubMed]
4. Hoult, J.R.S.; Paya, M. Pharmacological and Biochemical Actions of Simple Coumarins: Natural Products with Therapeutic Potential. *Gen. Pharmacl.* **1996**, *27*, 713–722. [CrossRef]
5. Go, M.L.; Wu, X.; Liu, X.L. Chalcones: An Update on Cytotoxic and Chemoprotective Properties. *Curr. Med. Chem.* **2005**, *12*, 483–499. [CrossRef]
6. Liu, M.; Wilairat, P.; Go, M.-L. Antimalarial Alkoxylated and Hydroxylated Chalcones: Structure-Activity Relationship Analysis. *J. Med. Chem.* **2001**, *44*, 4443–4452. [CrossRef] [PubMed]
7. Suwito, H.; Jumina, M.; Pudjiastuti, P.; Fanani, M.Z.; Kimata-Ariga, Y.; Katahira, R.; Kawakami, T.; Fujiwara, T.; Hase, Y.; Mohd Sirat, H.; et al. Design and Synthesis of Chalcone derivatives as Inhibitors of the Ferredoxin-Ferredoxin-$NADP^+$ Reductase Interaction of Plasmodium falciparum: Pursuing New Antimalarial Agents. *Molecules* **2014**, *19*, 21473–21288. [CrossRef] [PubMed]
8. Nielsen, S.F.; Boesen, T.; Larsen, M.; Kristian, S.; Kromann, H. Antibacterial Chalcones—Bioisosteric Replacement of the 4′-hydroxy Group. *Bioorg. Med. Chem.* **2004**, *12*, 3047–3054. [CrossRef] [PubMed]
9. Suwito, H.; Krsitanti, A.N.; Hayati, S.; Dewi, S.R.; Amalina, I.; Puspaningsih, N.N.T. Antimicrobial Activities and In silico Analysis of Methoxy Amino Chalcone Derivatives. *Procedia Chem.* **2016**, *18*, 103–111. [CrossRef]
10. Su, Y.-K.; Huang, W.-C.; Lee, W.-H.; Bamodu, O.A.; Zucha, M.A.; Astuti, I.; Suwito, H.; Yeh, C.-T.; Lin, C.-M. Methoxyphenyl Chalcone Sensitizes Aggresive epithelial Cancer to Cisplatin Through Apoptosis Induction and Cancer Stem Cell eradication. *Tumor Biol.* **2017**, *39*, 1–12. [CrossRef] [PubMed]
11. Kurt, B.Z.; Kandas, N.O.; Dag, A.; Sonmez, F.; Kucukislamoglu, M. Synthesis and biological evaluation of novel coumrine-chalcone derivatives containing urea moiety as potential anticancer agents. *Arab. J. Chem.* **2017**. [CrossRef]
12. Rowatt, B.; Herlihy, S.; Davidson, R. Ketocoumarins as Photoinitiators and Photosensitizers in Inks. Eur. Pat. Appl. EP2870147A1, 27 July 2012. Available online: https://patents.google.com/patent/EP2870147A1 (accessed on 23 October 2018).
13. Tabata, K.; Motani, K.; Takayanagi, N.; Nishimura, R.; Asami, S.; Kimura, Y.; Ukiya, M.; Hasegawa, D.; Akihisa, T.; Suzuki, T. 4-Hydroxyderricin from Angelica keiskei Roots Induces Caspase-dependent Apoptotic Cell Death in HL60 Human Leukemia Cells. *Biol. Pharm. Bull.* **2005**, *28*, 1404–1407. [CrossRef] [PubMed]

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