



BIOLOGICAL PROFILE OF COUMARINS (7-HYDROXY-4-METHYL-2H-BENZOPYRAN-2-ONES)

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ABSTRACT

Coumarins constitute an important group of biologically active compounds. These 2H-benzopyran-2-ones are widespread in nature and have been reported to possess various biological and/or pharmacological properties. They are known to possess inhibitory activity on platelet aggregation, antibacterial, anti-allergic, anti-inflammatory, anti-oxidant, anti-insecticidal, antiviral, anticoagulant, anticancer, antifungal, anti-HIV and antibiotic activities. Besides these, some of them also show cytotoxic, molluscicidal, spasmolytic, insecticidal, pesticidal and herbicidal activities. 7-Hydroxy-4-methyl-2H-benzopyran-2-ones belongs to an old class of naturally occurring coumarins. They are broadly used in photochemistry or cosmetics, seasonings and pharmaceuticals production. It has been evidenced from literature survey that these compounds possessed antibacterial, antifungal, anti-neoplastics, anti-HIV and antipsychotic activities. The unique structural scaffold and medicinal importance of coumarin have therefore attracted many Scientists in the past, to isolate or synthesize coumarin or their analogs as potential drug candidates. Though few reviews have been published in the past, mainly focusing all coumarins and their derivatives, but there is not a single separate review which is based on 7-hydroxy-4-methyl-2H-benzopyran-2-ones. We therefore have made efforts to briefly summarize 7-hydroxy-4-methyl-2H-benzopyran-2-one and their derivatives possessing biological activities in this review.

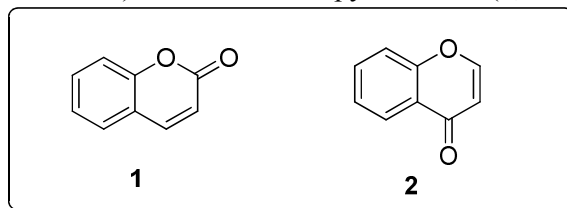
KEYWORDS: Coumarin, 7-hydroxy-4-methyl-2H-benzopyran-2-ones, antibacterial, anticoagulant, anticancer and antibiotic activities.

INTRODUCTION

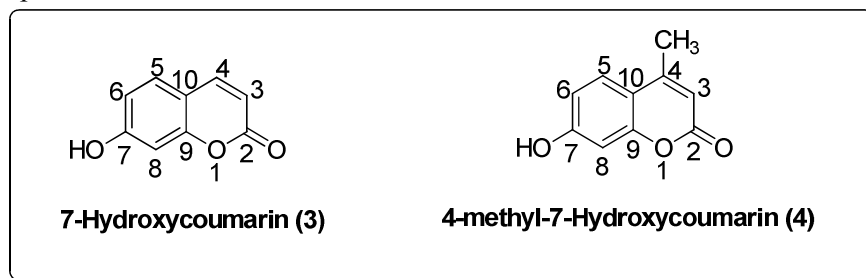
Coumarin is a large class of natural extract products, it considered to be the secondary metabolites in many higher plants species, particularly in leaves, seeds and roots, especially exists in the Rutaceae and Umbrelliferae plants. It was been found in the tonka bean and the name of coumarin comes from a French word coumarou. Coumarin plays an important role in regulation of plants growth and metabolites.¹ Coumarins have a wide variety of industrial importance. Due to their strong fragrant odour, coumarins are used as sweeteners, fixative of perfumes, enhancers of natural oils such as lavender, food additive in combination with vanillin, flavour/odour stabilizer in tobaccos, odour masker in paints and rubbers.

The name **Coumarin (1)** originates from the Caribbean word ‘*Coumarou*’ for the tonka tree, which was known botanically at one time as ‘*Coumarouna odorata*’ Aubl.^{II} Coumarin is now the accepted trivial name for the group of naturally occurring lactones which possess skeleton **1** as a fundamental structural unit.

The isolation of coumarin was first reported by Vogel^I in Munich in 1820. He associated the pleasant odour of the tonka bean from *Guiana* with that of clover, *Melilotus officinalis*, which gives rise to the characteristic aroma of new-mown hay. It was later synthesized by Perkin^{III} in 1868. Coumarins usually occur as secondary metabolites and are present in the seeds, roots, stems and leaves of many plant species, especially of *Leguminosae*, *Orchidaceae*, *Rutaceae* and the *Umbeliferae*^{IV} families. Coumarins have been also found in small amount in fungi and bacteria.^V The enormous number of coumarins that occur in nature is due to the multifarious ways in which ether formation takes place with different hydroxy groups in the benzenoid moiety. Almost all coumarins bear oxygenation at one or more of the six available nuclear positions. Benzopyran is a polycyclic organic compound that results from the fusion of a benzene ring to a heterocyclic pyran ring. **Benzopyrone** refers to the ketone derivatives of benzopyran which constitute the core skeleton of many flavonoid compounds. There are two isomers of benzopyrones depending on the orientation of the ketone group, resulting in *2H*-chromen-2-one (**1**, coumarin) and *4H*-1-benzopyran-4-one (**2**, chromone).



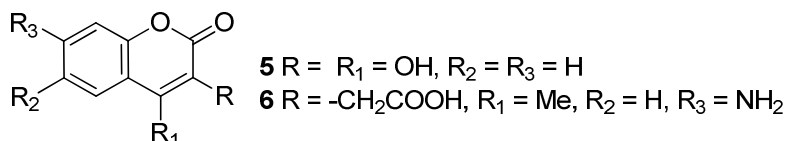
Coumarins, which according to the IUPAC nomenclature are known as **2H-chromen-2-ones (1)**, are important family of oxygenated heterocyclic compounds. A feature common to most coumarins is oxygenation at C-7 position. The 7-hydroxycoumarin, commonly known as Umbelliferone (**3**), is often regarded as the parent, both structurally and biogenetically, of the more complex coumarins.^{VI} It has been observed that coumarins carrying the 4-methyl function have much stronger cholestatic property than those lacking this functionality; furthermore the metabolites of 4-methyl coumarins are rapidly excreted with respect to metabolites of other coumarin. Our group in the past few years has been actively engaged in studying the chemistry and biological effects of 4-methyl-2*H*-1-benzopyran-2-one (**4**) and its related compounds.^{VII-VIII}



It has been observed that coumarins carrying the 4-methyl function have much stronger cholestatic property than those lacking this functionality; furthermore the metabolites of 4-methyl coumarins are rapidly excreted with respect to metabolites of other coumarin. 4-Methyl-2*H*-1-benzopyran-2-one, having two hydroxy or two acetoxy groups in the benzenoid ring at position *ortho* to each other, have shown very strong antioxidant and radical scavenging properties, better than those of α -tocopherol.^{IX} The investigation of the

mechanism of inhibition of liver microsome-catalysed AFB₁-DNA binding of 7,8-diacetoxy-4-methyl-2H-1-benzopyran-2-one and its potential use as an antimutagen.^X

Umbelliferone (**3**) is mainly used in the perfumery industry, sun-screens and as a fluorescent brightener while other derivatives of coumarins are used as pumpable laser dyes or for the photographic purposes because of its triplet excited-state. They are also used in electroplating to reduce the porosity and increase the brightness of various deposits, like nickel. The compounds (**5**, **6**) is also used as a fluorescent label for labelling antibodies and lectins for staining.^{XI}



The potential pharmacological profiles of coumarin and comparatively less toxicities have led the interest of many researchers to explore the utility of this moiety for better and varied pharmacological activities. Since the great variability of pharmacological response of coumarins is connected to large modifications of their substituents, the coumarin derivatives may be explored as potent biodynamic compounds. Owing to the diverse biological activities associated with these 4-methyl-2H-1-benzopyran-2-ones, and in the absence of compounds containing alkyl/alkenyl chain at position 4 in the pyran ring, we thought to summarize the biological profile of 4-methyl-7-hydroxycoumarins, which will have better biological importance than the simple coumarins. Presence of the substitution at these 4 and 7 positions will certainly increase the interest to the compound and will attract the attention for future.

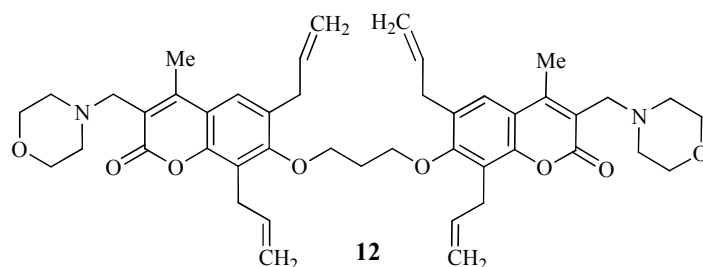
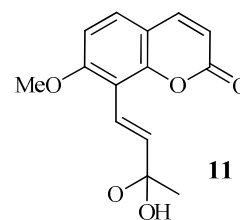
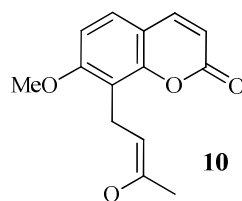
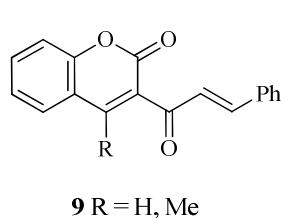
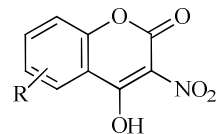
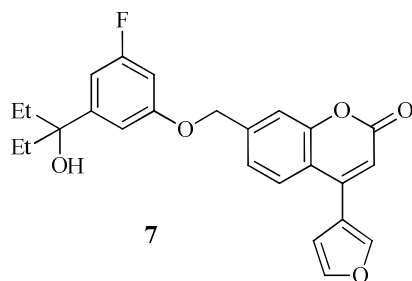
BIOLOGICAL ACTIVITIES

Coumarins have been also found to possess various biological and pharmacological activities as summarized below.

Coumarins exhibit many bioactivities such as: anticoagulant, estrogenic, dermal photosensitizing activity, antimicrobial, vasodilator, molluscicidal, anthelmintic, sedative, hypnotic, analgesic and hypothermal activity.^{XII-XIV} In fact, the diversity of bioactivities among coumarins is so huge that the term “pharmacological promiscuity” has been applied on their case.^{XV} Some of these biological actions are described as following:

Antiasthmatic, Antiallergic and antiinflammatory activities

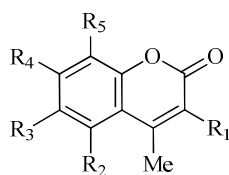
The bisarylcarbinol derivatives of coumarin (**7**) are useful as antiasthmatic, antiallergic and antiinflammatory for treating angina, cerebral spasm, hepatitis and in preventing the formation of arterosclerotic plaques.^{XVI} Various nitro coumarins (**8**) were found to show antiallergic activity in rats.^{XVII} Oganesyana *et al.*^{XVIII} reported the antiallergic activity of 4-substituted-3-cinnamoylcoumarin derivatives (**9**). Osthol (**10**) and Murraol (**11**) isolated from *Imperatoria ostruthium* and *Murraya exotica* respectively showed antiallergic activity.^{XIX} Coumarin derivative **12** has been recently synthesised and found to be antiallergic.^{XX}



Antioxidant activity

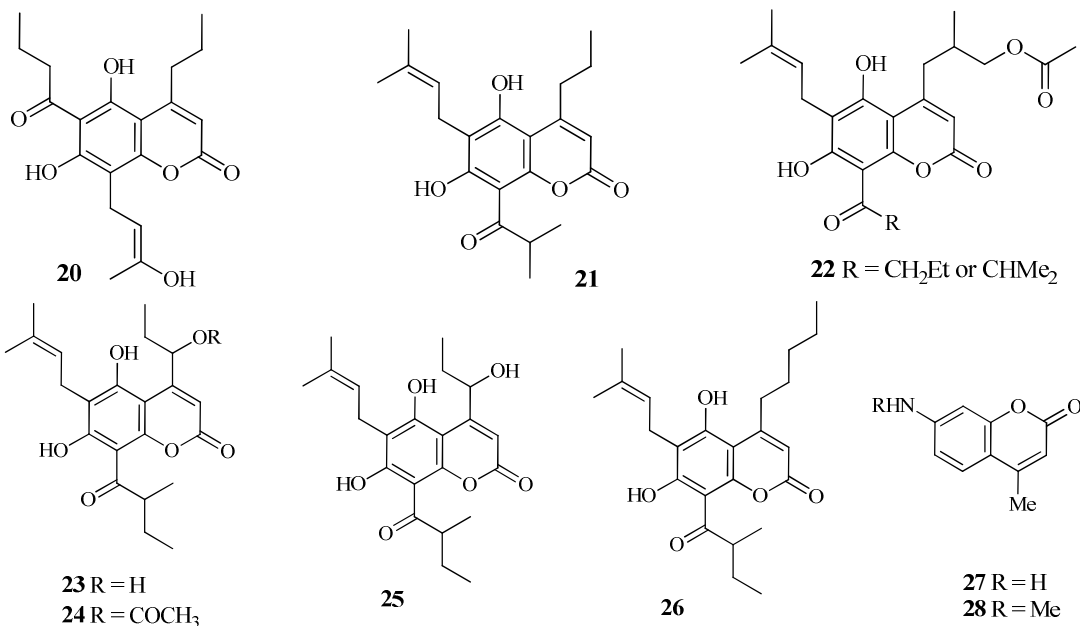
The reactive oxygen species in living cells cause various diseases including hepatic and vascular diseases. Efforts to discover antioxidants as useful drug candidates to combat these diseases are going on relentlessly. In this connection, minor dietary constituents, especially plant-based foods have come under serious scrutiny. Polyphenolic compounds have drawn greater attention compared to any other class of natural products to counter the ill effects of oxygen radicals. 4-Methylcoumarins (**13-19**) are known to possess several beneficial pharmacological effects. Their effects were also examined by our group on liver microsomal lipid peroxidation and radical scavenging. 4-Methylcoumarins having two hydroxy or two acetoxy groups in the benzenoid ring at the positions *ortho* to each other have shown very strong antioxidant and radical scavenging properties, better than those of α -tocopherol.^{XXI}

	R ₁	R ₂	R ₃	R ₄	R ₅
13	H	OH	H	OH	H
14	CH ₂ CH ₂ COOC ₂ H ₅	OH	H	OH	H
15	H	H	H	OH	OH
16	H	H	OCOCH ₃	OCOCH ₃	H
17	CH ₂ COOC ₂ H ₅	H	H	OCOCH ₃	H
18	H	H	H	OCOCH ₃	H
19	H	OMe	H	OMe	H



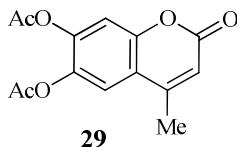
Insecticidal and Pesticidal activity

Coumarins and their derivatives also show insecticidal activity. Coumarins (**20-26**) showed insecticidal and pesticidal properties.^{XXII-XXV} 7-Amino-4-methyl coumarin (**27**) and its derivative (**28**) showed high insect-antifeedant activity.^{XXVI}



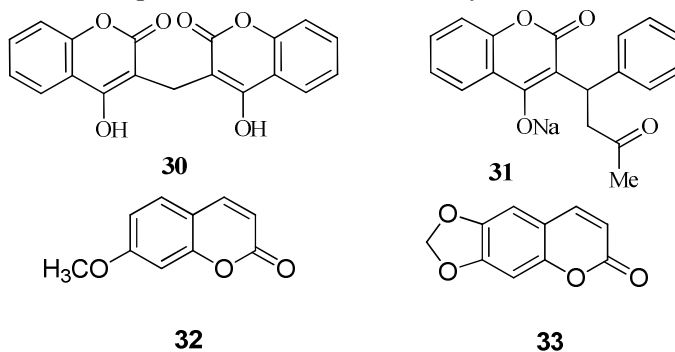
Antiviral activity

Coumarins are also known to possess antiviral activities. 6,7-Diacetoxy-4-methylcoumarin (**29**) was found to be active against *Herpes simplex virus* (HSV) and to a lesser degree against *Poliomyelitis virus*, however **18** was found to be active against *Poliomyelitis virus*.^{XXVII}



Anticoagulant activity

3,3'-Methylenebis(4-hydroxycoumarin) commonly known as dicoumarol (**30**) is best known for its anticoagulant effect on blood. Warfarin (**31**) showed anticoagulant activity and is also used as rodenticide.^{XXVIII} It is interesting that several coumarins show the opposite activity to warfarin. For example, while 4-hydroxycoumarins have anticoagulant activity, hemiarin (**32**) and ayapin (**33**) are shown to possess a hemostatic activity both *in vitro* and *in vivo*.^{XXIX}

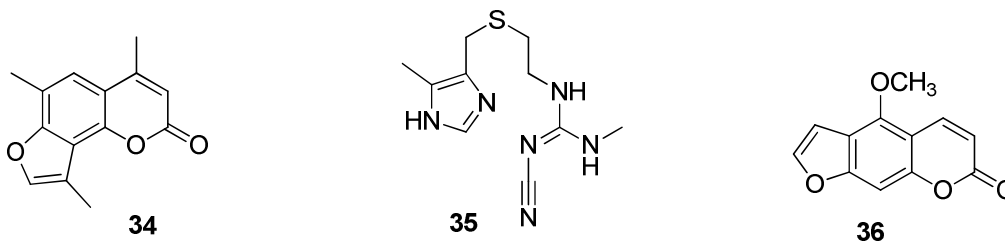


Antimitotic and Anticancer Activity

Coumarin and its derivatives, including 4-hydroxycoumarins and furanocoumarins inhibit mitosis in *Allium cepa* L. bulb cells.^{XXX} In human, a case of mycosis fungoides that was treated with topical PUVA therapy [combination treatment which consists of Psoralens (P) and then exposing the skin to UVA (long wave ultraviolet radiation)] using 4,6,3'-TMA (trimethylangelicin, **34**) exhibited no side effects or changes in the normal values of the

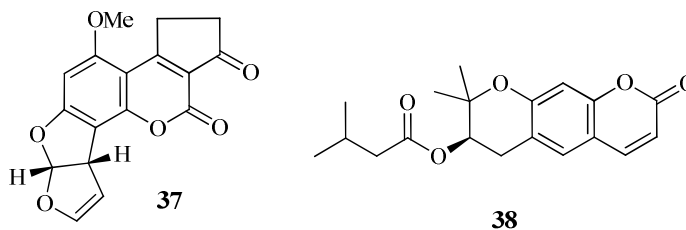
laboratory examinations.^{XXXI} Several other reports have demonstrated that coumarin in combination with cimetidine (**35**) can produce objective antitumor responses in some patients with advanced melanoma.^{XXXII-XXXIII}

There are reports that reviewed the clinical development of coumarin, with or without cimetidine (**35**), with special reference to renal cell carcinoma (RCC).^{XXXIV-XXXV} While objective tumor regressions were observed in renal carcinoma, no symptomatic or organ dysfunction toxicity was observed in any of the trials.^{XXXVI} Recently, xanthotoxin (**36**) has also been used in the treatment of cancer.^{XXXVII,XXXVIII}



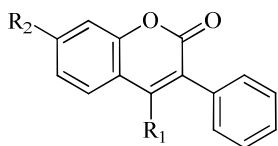
Anticancer

Aflatoxin is a highly toxic, mutagenic and carcinogenic compound. It is a secondary metabolite of the fungus *Aspergillus flavus*, found widely in large number of food commodities. Aflatoxin is a substituted coumarin, capable of causing covalent modification of nucleic acids and proteins on activation by *CYP450*. Epidemiological data suggest that aflatoxin B₁ (AFB₁) (**37**) may be an important etiological factor in human liver cancer in several parts of Asia and Africa.^{VIII} 4-Methylcoumarins showed inhibitory activity towards AFB₁-DNA binding.^{XXXIX} Decursin (**38**) on the other hand was found to show toxic activity against various human cancer lines.

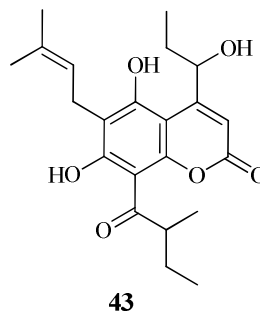


Fungicidal activity

Umbelliferone (**18**) was found to be antifungal from bioassays and can therefore be considered as phytoalexins.^{XL} 3-Phenylcoumarin (**39**), 4-methyl-3-phenylcoumarin (**40**), 7-methoxy-3-phenylcoumarin (**41**) and 4-hydroxy-3-phenylcoumarin (**42**) showed high antifungal activity *in vitro* against *Aspergillus parasiticus*, *Drechslera halodes*, *Fusarium moniliforme* and *Myrothecium verrucaria*.^{XLI} Assamene (**43**) show antifungal properties against pathogenic fungi, *Halominthosporium oryzae*, *Phytophthora oryzae*, *Alternaria solani*, *Curvularia eraglestidis* and *Collectotrichum glcosporioids*.^{XLII}

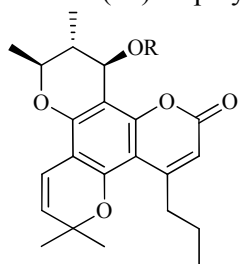


- 39 R₁ = H, R₂ = H
 40 R₁ = CH₃, R₂ = H
 41 R₁ = H, R₂ = OCH₃
 42 R₁ = OH, R₂ = H

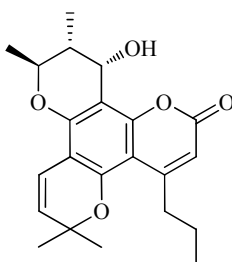


Anti-HIV activity

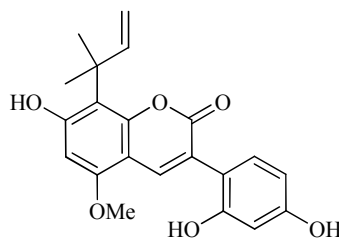
Coumarins and their derivatives displayed biological activity against HIV-I replication. The calanolide A (**44**), 12-acetoxycalanolide A (**45**), 12-methoxycalanolide A (**46**) and calanolide B (**47**), all having alkyl chain at C-4 position showed complete protection against HIV-I.^{XLIII} Licoarylcoumarin (**48**) displayed anti-HIV activity.^{XLIV}



- 44 R = H
 45 R = COCH₃
 46 R = CH₃



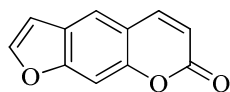
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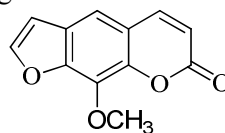
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Photodynamic Activity

Furanocoumarins are known to have photosensitizing activity in biological systems.^{XLV} Skin photosensitizing ability among angular furanocoumarins is much less than linear ones like psoralen (**49**). In the psoralen group, this activity varies depending on the structure.^{XLVI} As it is observed, psoralen (**49**) is the strongest skin photosensitizer in this group, while the hydroxyl derivatives and those with saturated 3,4- or 2',3'-double bond are almost inactive. Photochemotherapy of psoriasis by the application of 8-methoxypsoralen (methoxsalen, **50**) and long wave UV in patients has ended in promising results.^{XLVII,XLVIII}



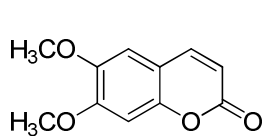
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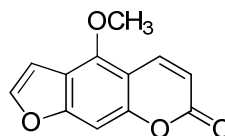
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Lipolytic Activity

Scoparone (6, 7-dimethoxycoumarin, **51**) has been purified from the hypolipidemic Chinese herb *Artemisia scoparia* and shown to reduce total cholesterol and triglycerides, and to retard the characteristic pathomorphological changes in hypercholesterolemic diabetic rabbits. 5-Methoxypsoralen (**52**) also can release and reduce cholesterol in atheromatous plaques. These activities have been attributed to various properties of coumarins including ability to scavenge reactive oxygen species, inhibition of tyrosine kinases, and potentiation of prostaglandin generation. The change in autoxidation of cholesterol can lead to an increase in its polarity and thus solubility, thereby facilitating the uptake by lipoproteins.^{XLIX}



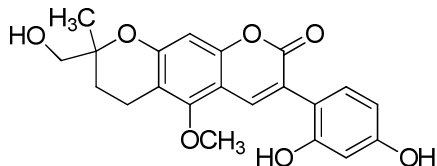
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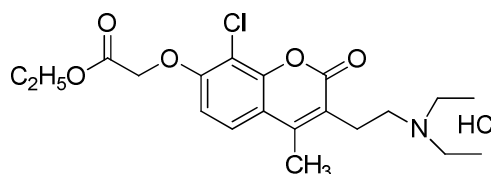
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Antiplatelet Activity

GU-7, a 3-aryl coumarin derivative (**53**), has been isolated from *Glycyrrhizae radix*, which is a crude herbal medicine. GU-7 caused inhibition of platelet aggregation, phosphorylation of 40K and 20K dalton proteins, inositol 1,4,5-trisphosphate production, intraplatelet calcium increase and phosphodiesterase activity *in vitro*. Cloricromene (**54**), a synthetic coumarin derivative, also possesses antithrombotic-antiplatelet activity.^L Some of these properties of cloricromene have been attributed to the inhibition of arachidonate release from membrane phospholipids.



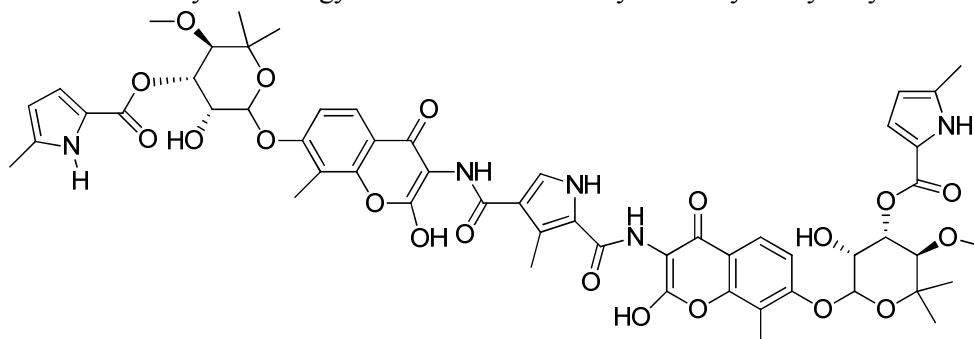
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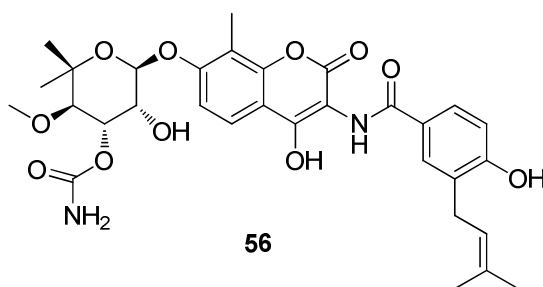
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Antibacterial and Antiparasitic

Dicoumarol (**30**) has excellent activity against many bacteria including *Bacillus anthracis*, *Staphylococcus aureus*, *Staphylococcus albus*, *Streptococcus pyogenes* and *Pasteurella avicida*.^{51,52} Although most of the natural coumarins have been isolated from plants, the aminocoumarin antibiotics coumermycin A1 (**55**) and novobiocin (**56**) were isolated from diverse *Streptomyces sp.* and exhibit a potent activity against Gram-positive bacteria. These compounds target the bacterial enzyme DNA gyrase and inhibit the enzyme-catalyzed hydrolysis of ATP.^{L1}



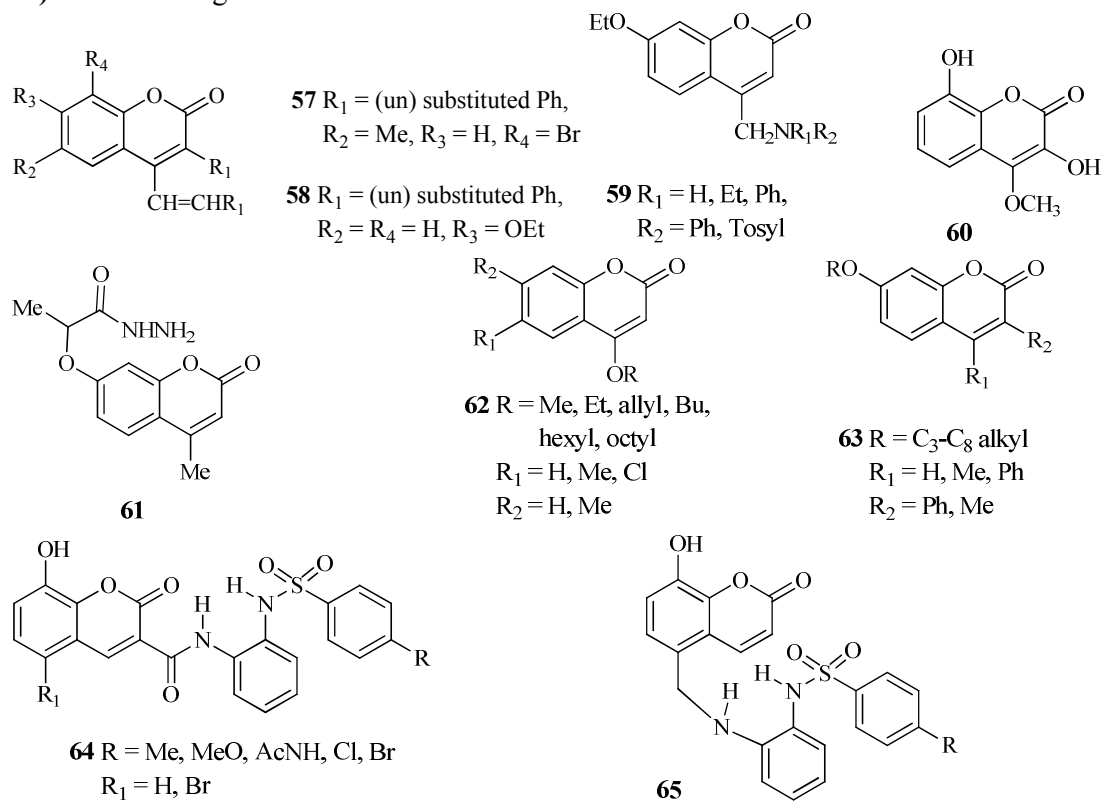
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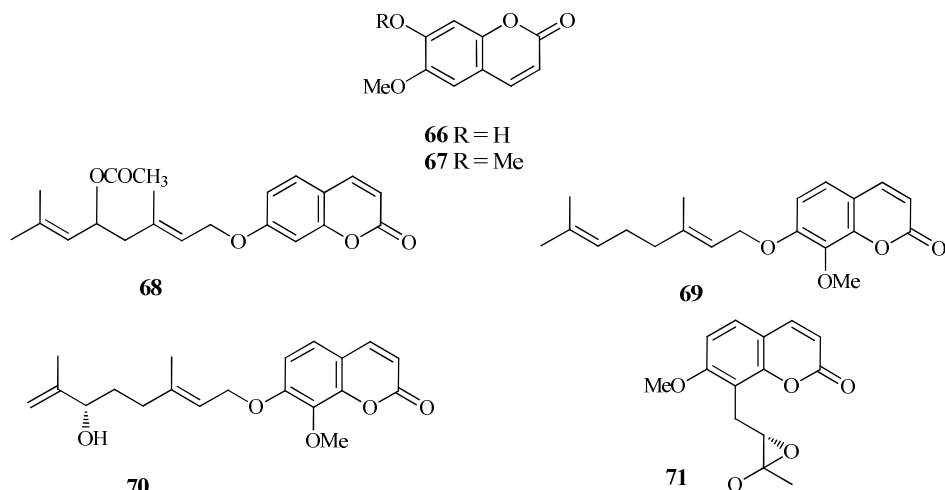
Due to toxicity of sulpha drugs (used for the cure of bacterial infections in humans) continuous search for other alternatives were carried out and coumarins were found to show

antibacterial activity. Naik *et al.*^{LII} synthesized 3-phenyl-6-methyl-8-bromo-4-substituted styrylcoumarins (**57**) and reported their antibacterial activity. 7-Ethoxy-4-substitutedaminomethylcoumarins (**58**) were found to display antibacterial activity.^{LIII} 4-Substitutedstyrylcoumarins (**59**) were tested against *Staphylococcus aureus* and *Escherichia coli* and these compounds displayed good antibacterial activity.^{LIV} 3,8-Dihydroxy-4-methoxycoumarin (**60**) isolated from *Gerbera anandria*^{LV} also showed antibacterial activity. Coumarin such as (**61**) and some related derivatives were recently synthesised and they showed antibacterial effect.^{LVI} Coumarins (**62**) were also screened for their antibacterial activities. The lower alkyl ethers were more active towards *Xanthomonas citri*, *Bacillus subtilis*, *Escherichia coli* than the higher alkyl ethers of the corresponding hydroxycoumarins.^{LVII} Rao *et. al* synthesised some 7-O-alkyl-3,4-substituted coumarin (**63**) and reported their antimicrobial activity.^{LVIII} Coumarin sulfonamide derivatives such as (**64** & **65**) also showed good antibacterial effect.^{LIX}



Inhibitory activity on platelet aggregation

Coumarin derivatives exhibit antiplatelet activity against thrombin, arachidonic acid, collagen and platelet-activating factor (PAF) induced aggregation in washed rabbit platelets.^{LX} Scopoletin (**66**) and scoparone (**67**) exhibited a potent inhibitory effect on rabbit platelet aggregation.^{LXI} The acetoxy auraptin (**68**) isolated from *Zanthoxylum schinifolium* showed inhibitory activity on platelet aggregation *in vitro*.^{LXII} Three 6-alkylcoumarins were obtained from the roots of *Angelica pubescens*^{LXIII-LXV} and when tested on human platelet aggregation, showed significant activity. Collinin (**69**) and Schininallyl (**70**) both have a long alkyl chain attached to it and showed inhibitory activity on platelet aggregation *in vitro*.^{LXII} Meranzin (**71**) isolated from *Citrus aurantium* also showed this activity.^{LXII}



Antibiotics

Bacterial infections can be controlled with presently available antibacterial drugs or their combination. However, development of bacterial resistance to existing drugs is a serious problem in bacterial chemotherapy. There is a continuing need for new types of antibacterial agents without cross resistance to drugs in current use. Molecular biological research has revealed the mode of action for many compounds with antibacterial activity. Coumarins have been shown to interfere with biosynthesis through the inhibition of DNA gyrase (bacterial topoisomerase II). This mode of action is suitable for selective bacterial activity.^{LXVI} Wedelolactone (**72**) is a natural product, which is used as a venomous snake-bite antidote. Brachycoumarin^{LXVII} (**73**) and coumarin^{LXVIII} **74** have also been considered as potentially useful antibiotic.

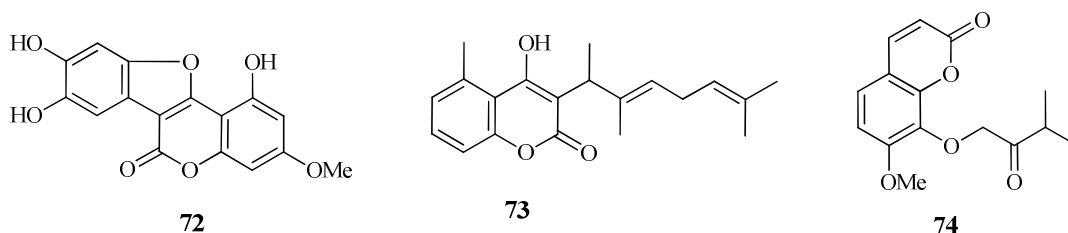
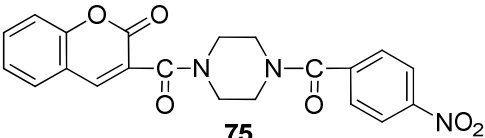
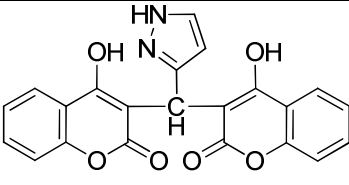
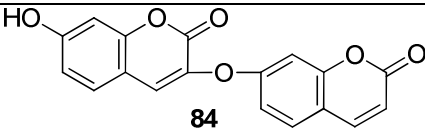
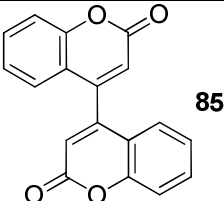
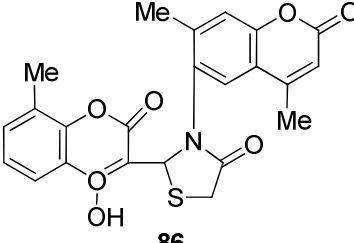
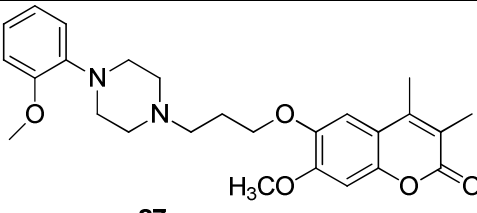
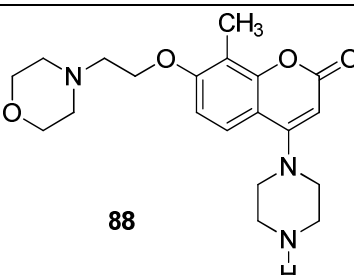
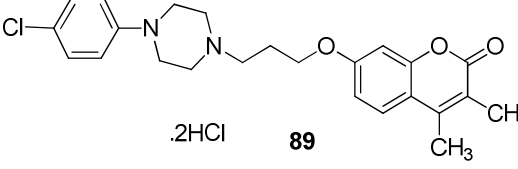
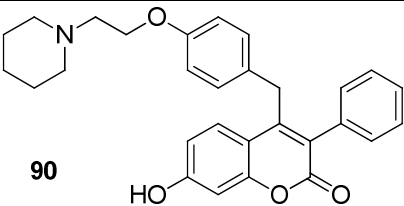
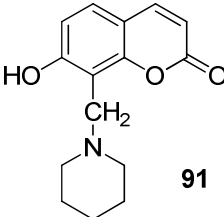
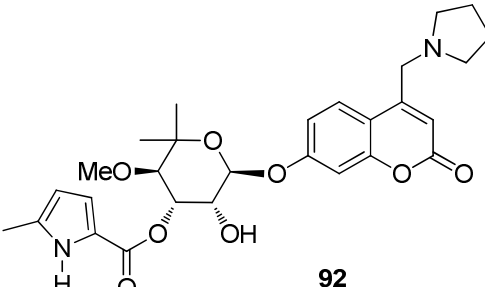


Table I have summarized various biological and pharmacological activities of discussed coumarin.

S. No.	Name of the Compound	Structure	Activity
1.	3-[[4-(4-Nitrobenzoyl)-1-piperazinyl] carbonyl]-2H-1-benzopyran-2-one	 <p>75</p>	Acetylcholinesterase inhibitory ^{LXIX}

2.	3-Acetyl-1-(4-carboxyphenyl)-4-hydroxy-2-oxo-2H-1-benzopyran-3-propanoic acid, 3-ethyl ester	<p style="text-align: center;">76</p>	Cytotoxic ^{LXX}
3.	4-Hydroxy-3-[3-oxo-1-(2-thienyl)butyl]-2H-1-benzopyran-2-one	<p style="text-align: center;">77</p>	Anticoagulant ^{LXXI}
4.	4-[(4-Acetyl-4,5-dihydro-5-methyl-1,3,4-oxadiazol-2-yl)methoxy]-2H-1-benzopyran-2-one	<p style="text-align: center;">78</p>	Antiviral Cytotoxicity ^{LXXII}
5.	3-[1-(4-Bromophenyl)-3-oxobutyl]-4-hydroxy-2H-1-benzopyran-2-one	<p style="text-align: center;">79</p>	Anticoagulant ^{LXXIII}
6.	4-[2-[5-(5-Chloro-2-hydroxyphenyl)-3-(3-chlorophenyl)-1H-pyrazol-1-yl]-2-oxoethoxy]-7-hydroxy-2H-1-benzopyran-2-one	<p style="text-align: center;">80</p>	Antimicrobial ^{LXXIV}
7.	6-Ethyl-4-methyl-7-[[5-(phenylamino)-1,3,4-thiazol-2-yl]methoxy]-2H-1-benzopyran-2-one	<p style="text-align: center;">81</p>	Antimicrobial ^{LXXV}
8.	N-[4-(4-Chlorophenyl)-7-methoxy-8-methyl-2-oxo-2H-1-benzopyran-3-yl]-3,4-dihydro-2,2-dimethyl-2H-1-benzopyran-6-carboxamide	<p style="text-align: center;">82</p>	Antiproliferative ^{LXXVI}

9.	3,3'-(1H-pyrazol-3-ylmethylene)bis[4-hydroxy-2H-1-benzopyran-2-one	 <p style="text-align: center;">83</p>	Anticoagulant ^{LXXXVII}
10.	7-Hydroxy-3-[(2-oxo-2H-1-benzopyran-7-yl)oxy]-2H-1-benzopyran-2-one	 <p style="text-align: center;">84</p>	Inhibitors of DNA polymerase ^{LXXXVIII}
11.	[4,4'-Bi-2H-1-benzopyran]-2,2'-dione	 <p style="text-align: center;">85</p>	Antifungal ^{LXXXIX}
12.	3-(4,7-Dimethyl-2-oxo-2H-1-benzopyran-6-yl)-2-(4-hydroxy-8-methyl-2-oxo-2H-1-benzopyran-3-yl)-4-thiazolidinone	 <p style="text-align: center;">86</p>	Antifungal ^{LXXX}
13.	7-Methoxy-6-[3-[4-(2-methoxyphenyl)piperazin-1-yl]propoxy]-3,4-dimethyl chromen-2-one	 <p style="text-align: center;">87</p>	Anti-AChE agent ^{LXXXI}
14.	8-Methyl-7-(2-morpholino-ethoxy)-4-(1-piperazinyl)-2H-chromen-2-one	 <p style="text-align: center;">88</p>	Invitro antiplatelet activity ^{LXXXII}
15.	3,4-Dimethyl-7-[4-chlorobenzyl piperazine-1-yl]propoxycoumarin dihydrochloride	 <p style="text-align: center;">89</p>	Anti-allergic ^{LXXXIII,LXXXIV}

16.	7-Hydroxy-3-phenyl-4-(4-(2-(piperidin-1-yl)ethoxy)benzyl)-2H-chromen-2-one	 <p style="text-align: center;">90</p>	Acts as potent antiestrogen in both <i>in vitro</i> and <i>in vivo</i> models of breast cancer ^{LXXXV}
17.	7-Hydroxy-8-piperidin-1-ylmethyl-chromen-2-one	 <p style="text-align: center;">91</p>	Anti inflammatory ^{LXXXVI}
18.	(3R,4S,5R,6R)-5-Hydroxy-3-methoxy-2,2-dimethyl-6-((2-oxo-4-(pyrrolidin-1-yl methyl)-2H-chromen-7-yl)oxy)tetrahydro-2H-pyran-4-yl 5-methyl-1H-pyrrole-2-carboxylate	 <p style="text-align: center;">92</p>	Antibacterial ^{LXXXVII}

CONCLUSION

Coumarin has attracted biological chemist due to its wide range of biological and pharmacological activities such as anti-tumor, anti-coagulant, anti-inflammatory, anti-oxidant, anti-HIV, anti-bacterial, anticoagulant and rheumatoid arthritis therapy. Coumarins have become the research hot point based on their different treatment effects to diseases and less damage to normal cells. We have made efforts to summarize various biological activities of 4-methyl-2H-1-benzopyran-2-one, especially the substitution at 4 and 7 positions in this communication.

CONFLICT OF INTERESTS

The author declares that there is no conflict of interests regarding the publication of this paper.

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