



CODEN [USA]: IAJ PBB

ISSN : 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

SJIF Impact Factor: 7.187

<https://doi.org/10.5281/zenodo.23100460>Available online at: <http://www.iajps.com>

Review Article

COUMARIN DERIVATIVES AS PROMISING THERAPEUTIC
AGENTS AN UPDATED REVIEWMallikarjun H, Kartik Havale, Sandhya D. Chinnamulagund*, Tabasum Killedar, V. H.
Kulkarni, Shrinivas D. JoshiNovel Drug Design and Discovery Laboratory, Department of Pharmaceutical Chemistry,
S.E.T's College of pharmacy, Sangolli, Rayanna Nagar, Dharwad 580 002, India**Abstract:**

Coumarin (2H-chromen-2-one) is a naturally occurring benzopyrone compound that has attracted considerable attention because of its wide range of biological activities and its importance in medicinal chemistry. Owing to its versatile chemical structure, coumarin serves as a valuable scaffold for the development of numerous therapeutically active compounds. This review provides an overview of the physicochemical and spectroscopic properties of coumarin, along with the major synthetic methods, including the Perkin, Pechmann, Kostanecki–Robinson, and Claisen rearrangement reactions. The characteristic IR and ¹H NMR spectral features used for the identification and structural confirmation of coumarin are also discussed. In addition, recent advances in the synthesis and biological evaluation of coumarin derivatives are summarized, highlighting their antimicrobial, antibacterial, antifungal, anti-tubercular, antioxidant, and anticancer activities. The review also discusses how structural modifications of the coumarin nucleus influence biological activity and improve therapeutic potential. Furthermore, selected commercially available coumarin derivatives and their pharmaceutical significance are briefly described. Overall, this review highlights the growing importance of coumarin as a versatile heterocyclic scaffold and its continued potential in the discovery and development of new bioactive molecules.

Keywords: Coumarin, Heterocyclic compounds, Medicinal chemistry, Drug discovery, Biological activity.

Corresponding author:**Mrs. Sandhya D. Chinnamulagund,**

Assistant professor, Dept. Of Pharma-Chemistry, S.E.T's

College of Pharmacy, S.R. Nagar, near microwave tower, Dharwad-580002,
Karnataka, India

Mobile: 8892964678

Email Id- sandhyachinnamulagund@gmail.com

QR CODE



Please cite this article in press **Sandhya D C et al., Coumarin Derivatives As Promising Therapeutic Agents
An Updated Review., Indo Am. J. P. Sci, 2026; 13(10).**

INTRODUCTION:

Coumarin (2H-chromen-2-one) is an oxygen-containing heterocyclic compound belonging to the benzopyrone family and is widely recognized as one of the most important privileged scaffolds in medicinal chemistry. Naturally occurring coumarins are present in numerous plant species and have attracted considerable scientific interest because of their structural diversity, ease of chemical modification, and wide range of biological activities. The fused benzene and α -pyrone ring system provides an excellent framework for the synthesis of novel derivatives with improved pharmacological properties, making coumarin an attractive template for drug discovery and development. [1, 2]

Over the past several decades, extensive research has been devoted to the synthesis and biological evaluation of coumarin derivatives. These compounds have demonstrated significant antimicrobial, antibacterial, antifungal, anti-tubercular, antioxidant, anti-inflammatory, anticoagulant, antiviral, and anticancer activities. Numerous structure–activity relationship (SAR) studies have shown that the biological profile of coumarin derivatives is strongly influenced by the type, number, and position of substituents on the coumarin nucleus. Consequently, strategic structural modifications have led to the development of derivatives with enhanced potency, improved selectivity, and reduced toxicity. [3, 4]

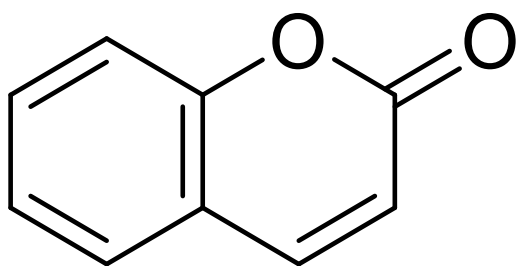
The versatility of coumarin chemistry has also resulted in the development of several efficient synthetic methods, including the Perkin, Pechmann, Kostanecki–Robinson, and Claisen rearrangement reactions, which remain valuable approaches for

constructing structurally diverse coumarin analogues. In addition, spectroscopic techniques such as infrared (IR) spectroscopy and proton nuclear magnetic resonance (^1H NMR) spectroscopy are routinely employed for the structural characterization and confirmation of coumarin derivatives. Beyond medicinal chemistry, coumarin derivatives have found applications as fluorescent probes, laser dyes, optical brighteners, fragrances, analytical reagents, and functional materials owing to their unique photophysical properties (Murray et al., 1982; Venugopala et al., 2013).[1, 2]

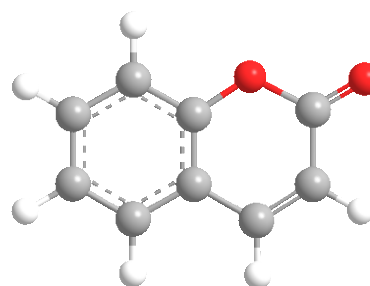
This review provides a comprehensive overview of coumarin chemistry, covering its physicochemical properties, spectroscopic characteristics, synthetic methodologies, and important chemical transformations. Particular emphasis is placed on recent advances in the synthesis and biological evaluation of coumarin derivatives, especially their antimicrobial potential. By summarizing recent developments in this field, this review highlights the continuing importance of the coumarin scaffold as a promising platform for the design and development of novel therapeutic agents.

CHEMISTRY OF COUMARIN COMPOUNDS

Coumarin (2H-chromen-2-one) is an oxygen-containing heterocyclic aromatic compound belonging to the benzopyrone family, consisting of a fused benzene and α -pyrone (lactone) ring. Its conjugated ring system and reactive lactone moiety make it an important scaffold for chemical modification, enabling the synthesis of numerous biologically active derivatives used in medicinal, pharmaceutical, and materials chemistry.[3]



1



2

2H-chromen-2-one

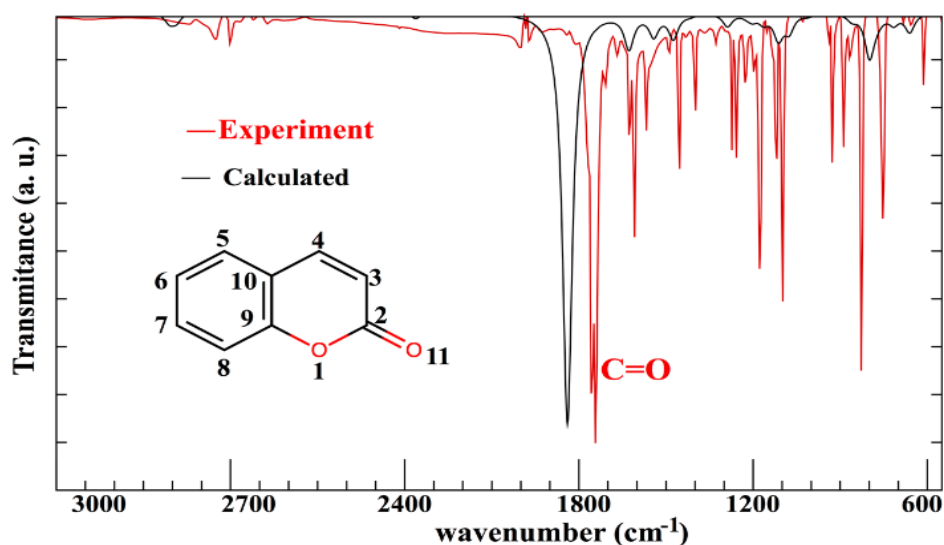
PHYSICAL PROPERTIES

Chemical Name	2H-chromen-2-one
Molecular Formula	C ₉ H ₆ O ₂
Synonyms	Coumarin, 1,2-Benzopyrone, Cumarin, 1-Benzopyran-2-one
Molecular Weight	146.14 g/mol
Physical State (Form)	Solid
Appearance/Colour	White to faintly yellow
Odour	Vanilla beans, Caramelized sugar
Boiling Point (BP)	298 °C
Melting Point (MP)	73 °C
Density	~ 0.935 g/cm ³ (at 20°C)
Vapour Pressure	Low volatility
Flash Point	162 °C
Solubility	Readily soluble in hot water
pKa (conjugate acid)	-6.9
Basic Nature	Weak base
Hydrogen Bonding	Acts as H-bond acceptor
Flammability	Not highly flammable
Toxicity	Moderately toxic to liver

SPECTROSCOPIC FEATURES

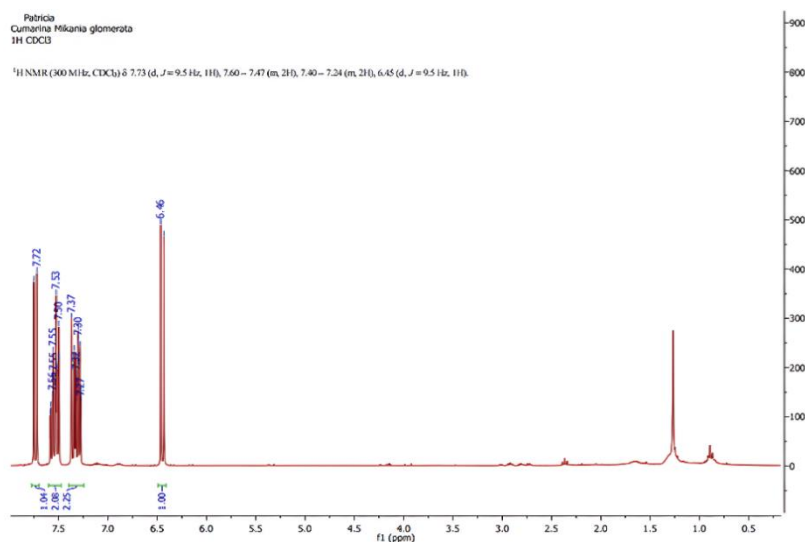
IR SPECTRA:

This IR spectrum belongs to Coumarin C₉H₆O₂. We can see aromatic C-H stretching around 3030-3100 cm⁻¹, C=O stretching around 1710-1730 cm⁻¹. The peak between 1600-1500 cm⁻¹ is due to the stretching is due to the stretching of aromatic C=C stretching and the signals below 1100 cm⁻¹ come from out of plane C-H bending.[5]



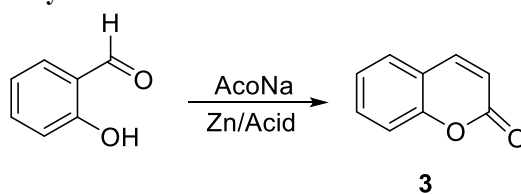
NMR SPECTRA:

This is ¹H NMR spectrum of coumarin shows six peaks at around 6.45, 7.73, 7.24, 7.40, 7.47 and 7.60 reflecting 6 distinct carbon environments in the ring. The signal near 6.45 and 7.73 corresponds to the alkenes in the system and other peaks arise from the aromatic carbons.[6]

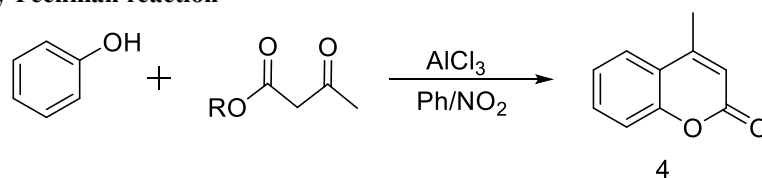


SYNTHESIS OF COUMARIN[7]

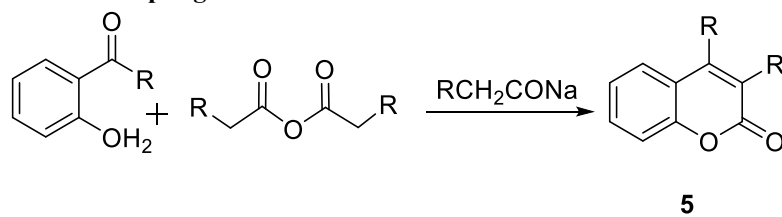
1. Synthesis of coumarin by Perkins reaction



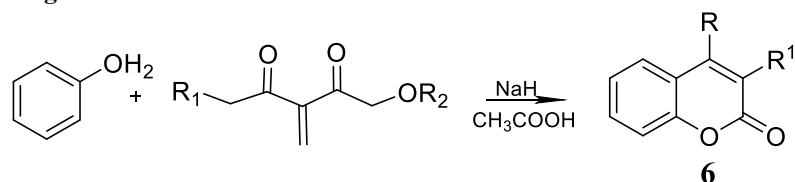
2. Synthesis by Pechman reaction



3. Kostanecki-Robinson Coupling reaction

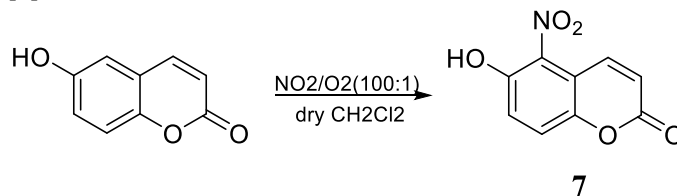


4. Claisen Rearrangement

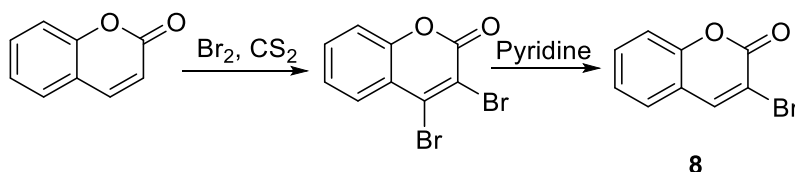


GENERAL REACTIONS OF COUMARIN

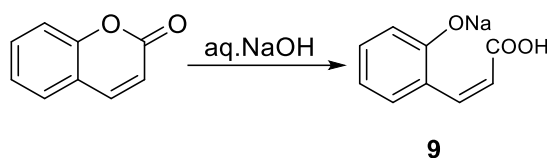
1. Nitration of coumarin[8]



2. Halogenation of coumarin[9]

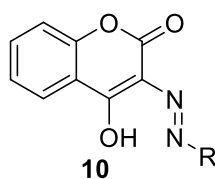


3. Action of alkali[10]



BIOLOGICAL ACTIVITY

P Sudhir Kumar et al. have reported Synthesis and Antimicrobial activity o some novel 4-Hydroxy Coumarin derivatives bearing azo moiety, Compounds **10b**, **10c**, **10g** and **10h** were exhibited excellent antibacterial activity against *E. coli* and *S. aureus*. [11]



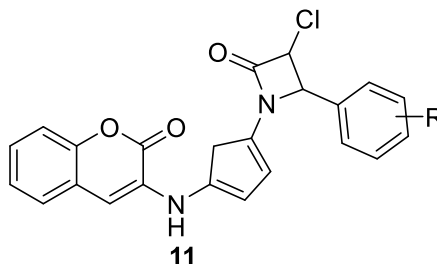
10a: R = 4-OCH₃C₆H₅

10b: R = 4-ClC₆H₅

10c: R = 4-NO₂C₆H₅

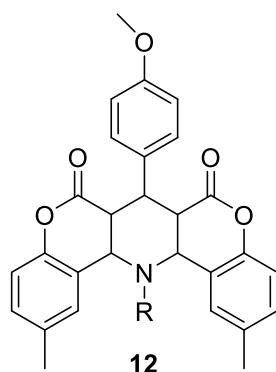
10d: R = 4-SO₃HC₆H₅

Indu Singh et al. have reported the synthesis of new coumarin derivatives as antibacterial agents, compound **11c** which was substituted with methoxy group at position 4th of phenyl ring showed potent anti-bacterial activity.[12]



11a: R = OCH₃

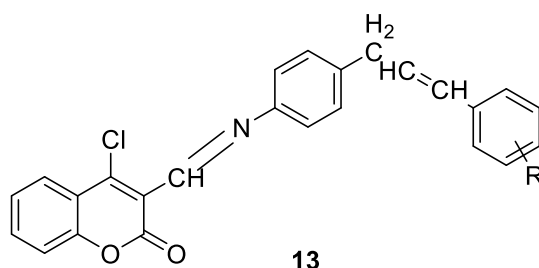
M K A Regal et al. have reported synthesis and antimicrobial activity of some new coumarin and dicoumarol derivatives, **12a**, **12b**, **12c** showed promising antibacterial and antifungal activity. The activity index value ranged between 50–88%.[13]



12a: R = H

12b: R = CH₃12c: R = C₆H₅CH₃

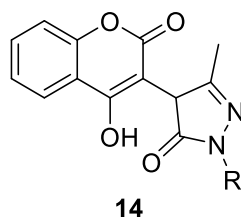
Sayali D *et al.* have reported Synthesis and valuation of some coumarin containing potential antimicrobial agents, compounds **13(a-g)** have shown good in-vitro antimicrobial activity against all the tested gram +ve and gram -ve bacteria and fungi.[14]



13a: R = H

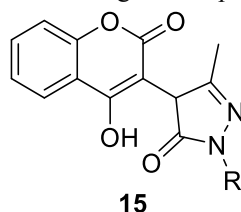
13e: R = *m*-NO13b: R = *p*-Cl13f: R = *o*-OH13c: R = *m*-Cl13g: R = *o*-Cl13d: R = *p*-NO₂

Biljana R *et al.* have reported Synthesis and Antimicrobial activity of new 4-Heteroarylmino, Coumarin derivatives containing nitrogen and oxygen as heteroatoms, 4-Chloro-3-nitro coumarin proved to be a good electrophilic substrate in these reactions.[15]

14a: R = -C₆H₅

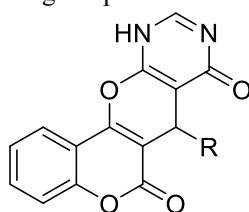
14a: R = -H

Chirag G. Naik *et al.* have reported Novel Coumarin derivatives; Synthesis, Characterization and Antimicrobial activity, compounds **15a** and **15b** show best performance against *Staphylococcus aureus* and *Bacillus subtilis*. [16]

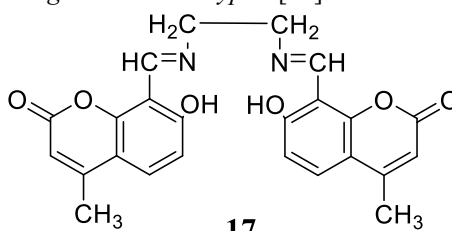
15a: R = -C₆H₅

15b: R = -H

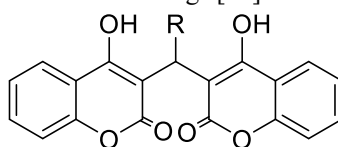
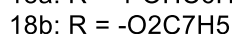
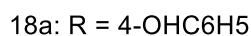
M. A. Al-Haiza et al. have reported Synthesis and Biological evaluation of some new coumarin derivatives, compound **16** showed excellent activity against gram positive bacteria.[17]

**16**

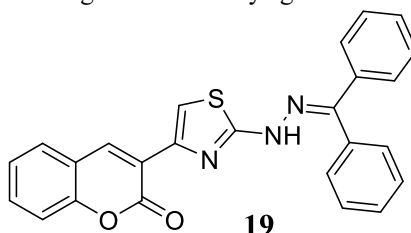
Ajaykumar Kularni et al. have reported Synthesis, characterization, DNA cleavage and in vitro antimicrobial studies of La (III), Th (IV), VO (IV) complexes with Schiff base of coumarin derivatives, Schiff bases were found to be highly active against *E. coli*, *P. aeruginosa* and *Sa. typhi*. [18]

**17**

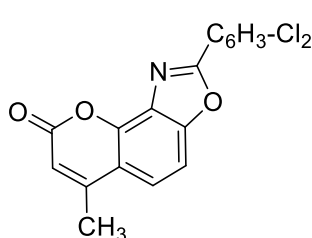
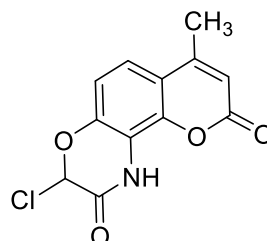
Sadia Rehman et al. have reported Synthesis, characterization, in vitro antimicrobial and U2OS tumoricidal activities of different coumarin derivatives, compound **18a** and **18b** have been found most active against U2OS cancerous cells than the previously reported tumoricidal drugs.[19]

**18**

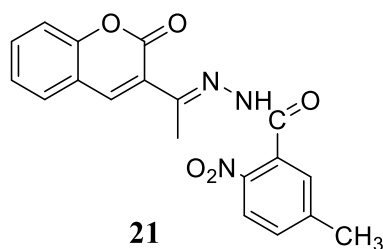
Afsheen Arshad et al. have reported Synthesis and antimicrobial properties of some new thiazolyl coumarin derivatives, inhibitors compound **19** showed significant activity against all microbial strains.[20]

**19**

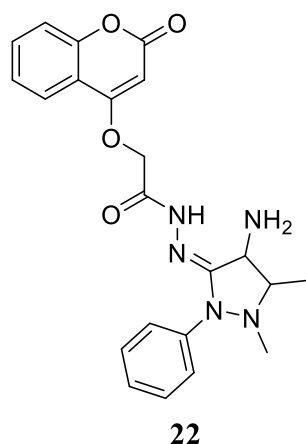
Swayam Sourov Sahoo et al. have reported Synthesis of novel coumarin derivative and its biological evaluations[21]

**20a****20b**

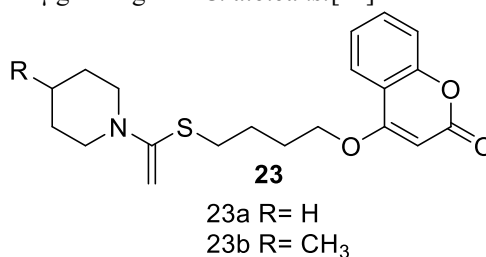
Tariq T et al. have reported Synthesis, characterization and antibacterial evaluation of some coumarin derivatives, The highest activity was demonstrated by compound K2 (ionized containing NO₂ which is a strong electron withdrawing group) which was found to be highly active against *Pseudomonas aeruginosa*. [22]



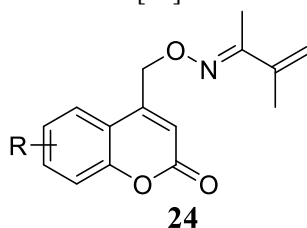
Nadia betti et al. have reported Harnessing coumarin chemistry: Antibacterial, antifungal and antioxidant profiling of novel coumarin derivatives, compound **22** demonstrating the most potent antibacterial effects against all bacterial species tested.[23]



Piotr Wilinski et al. have reported Coumarin-dithiocarbamate derivatives as biological agents, **23a** and **23b** showed the most potent activity. Derivative 23a exhibited a MIC value of 0.5 µg/mL against *A. flavus*, *T. harzianum*, and *P. chrysogenum*, and 1 µg/mL against *C. albicans*. [24]

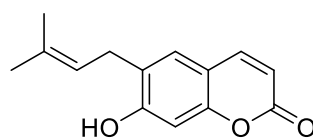


Dinesh S. Reddy et al. have reported synthesis and evaluation of novel coumarin-oxime ethers as potential anti-tubercula agents: Their DNA cleavage ability and BSA interaction study, analogues (**24a–24j**) as potent anti-tubercular agents. Most of the compounds exhibited significant activity with MIC in the range 0.04–3.12 µg mL⁻¹ along with good safety profile against Vero cells.[25]

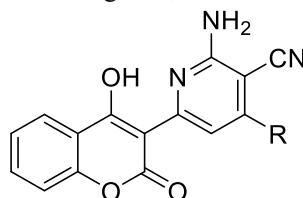


- | | |
|--|--|
| 24a: R = 6-CH ₃ | 24f: R = 7-Cl |
| 24b: R = 6-Cl | 24g: R = 7-CH ₃ |
| 24c: R = 6-OCH ₃ | 24h: R = 5,7-diCH ₃ |
| 24d: R = 5,6-C ₆ H ₄ | 24i: R = 7,8-C ₆ H ₄ |
| 24e: R = 7,8-diCH ₃ | 24j: R = 6-Br |

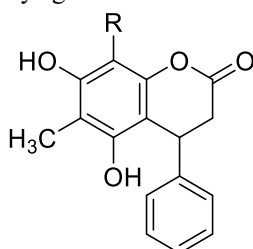
Weerachai Phutdhawong et al. have reported Synthesis and biological activity evaluation of coumarin-3-carboxide derivatives, compounds **25**, which showed moderate antibacterial activities against the tested gram-positive bacteria.[26]

**25**

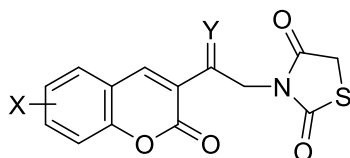
Sadeq M. Al-Hazmy et al. have reported chemo sensing properties of coumarin derivatives: Promising with diverse pharmacological properties, Docking and DFT investigation, *Molecules* 2022, 27(18), 5921[27]

**26**

Tulla Quadri-Spinelli et al. have synthesized bioactive coumarin derivatives from the fern cyclosorus interruptus, compound 27 showed strong antibacterial activity against *Bacillus cereus* and *Staphylococcus epidermidis*. [28]

**27**

Shahram Ghodsi et al. have synthesized and characterized of some new thiazolidinedione derivatives containing a coumarin moiety for their antibacterial activities, compounds **28a**, **28b** and **28c** exhibit the most potent in-vitro antibacterial activity[29]

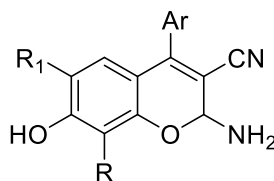
**28(a-c)**

28a: X = H, Y = NOCH₃

28b: X = 6-Br, Y = NOCH₃

28c: X = 8-OCH₃, Y = NOCH₃

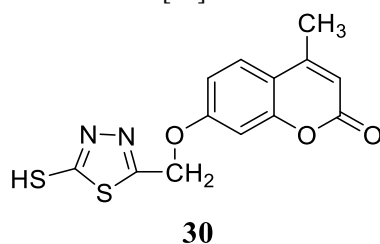
Ahmed M. El-Agrody et al. have reported synthesis of hydroxyquinolone derivatives, Amino-Hydroxychromene, Amini coumarin and their anti-bacterial activities, compounds **29a** and **29b** exhibited antibacterial activity against *S. aureus*. [30]

**29 (a-b)**

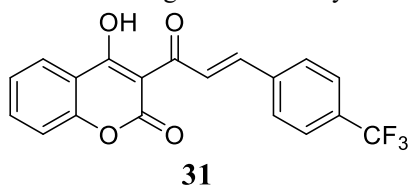
29a: R = H ; R₁ = H ; Ar = p-ClC₆H₄

29b: R = H ; R₁ = -C₂H₅ ; Ar = p-ClC₆H₄

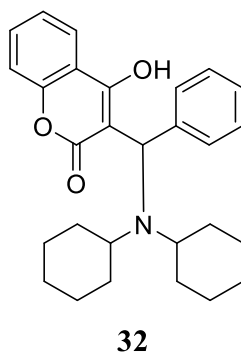
Gabriela Tatarina et al. have prospected antimicrobial activity of some coumarin derivatives, compound **30** was very active against these two Gram positive bacteria. [31]



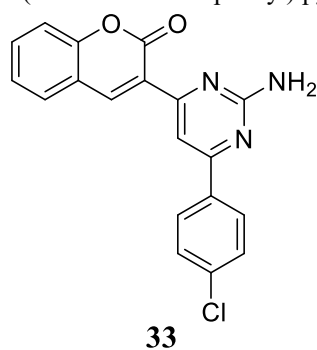
Selma Špirtović-Halilović et al. have performed synthesis, Microbiological activity and *In-Silico* investigation for some synthesized coumarin derivatives, the structure was confirmed using NMR spectroscopy and Mass spectrometry. Microbiological studies have shown significant activity of these compounds.[32]



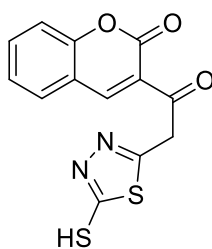
Pooja Tandel et al. have investigated recent advancement in the pharmacological potential of C-3 substituted coumarin derivatives against *S. aureus*.[33]



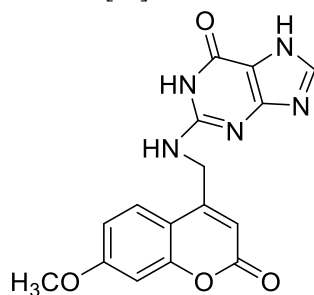
Mohd Imran et al. have reported synthesis and anti-microbial activity of some 2-Amino-4-(7-substituted/unsubstituted coumarin-3-yl)-6-(chlorosubstitutedphenyl) pyrimidines.[34]



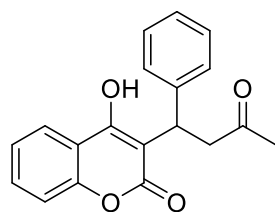
Riyadh Ahmed et al. have reported synthesis of new coumarin derivatives containing aminobenzotriazole, triazole moieties and their antimicrobial activities.[35]

**34**

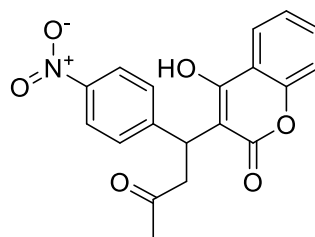
Krešimir Benci et al. have reported synthesis and evaluation of novel coumarin derivatives containing 1,2,4-triazole, 4,5-Dicynoimidazole and purine moieties.[36]

**35**

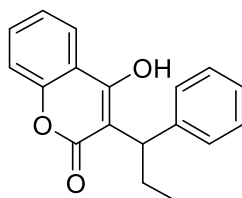
PHARMACOLOGICALLY ACTIVE MARKETED DRUGS CONTAINING COUMARIN RING



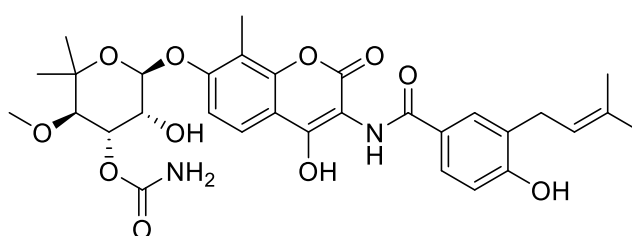
warfarin



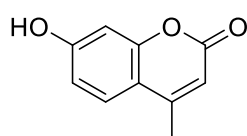
Acenocoumarol



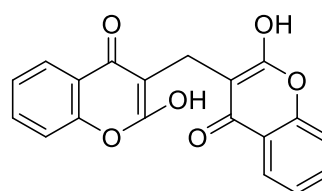
Phenprocoumon



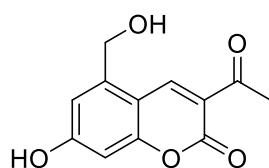
Novobiocin



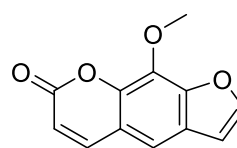
Hymecromone



Dicoumarol



Armillarisin A



Methoxsalen

CONCLUSION:

Coumarin has emerged as one of the most versatile and extensively studied heterocyclic scaffolds in medicinal chemistry because of its structural diversity and broad spectrum of biological activities. The literature reviewed in this article demonstrates that continuous modifications of the coumarin nucleus have resulted in the development of numerous derivatives with promising antimicrobial, antibacterial, antifungal, anti-tubercular, antioxidant, and anticancer properties. The availability of efficient synthetic methods has enabled researchers to design structurally diverse analogues with enhanced biological activity and improved selectivity. Beyond its pharmaceutical importance, coumarin also has significant applications in fragrances, dyes, fluorescent probes, and analytical chemistry. Despite the considerable progress achieved so far, there remains ample scope for exploring new coumarin derivatives with better efficacy, lower toxicity, and well-defined mechanisms of action. Future research integrating synthetic chemistry, computational approaches, and biological evaluation is expected to accelerate the discovery of novel coumarin-based therapeutics. Overall, coumarin continues to be a valuable and promising scaffold that offers immense opportunities for the development of safer and more effective drugs for the management of infectious and other chronic diseases.

ACKNOWLEDGEMENT:

We thank Dr. H. V. Dambal, President and Dr. V. G. Jamakandi, Dean SET's College of Pharmacy, Dharwad, Karnataka, for providing the facilities.

REFERENCES:

- [1] Murray RDH., Méndez J., Brown SA. The natura, coumarins: Occurrence, Chemistry and Biochemistry. 1983; 702.
- [2] Venugopala KN, Rashmi V, Odhav B. Review on Natural Coumarin Lead Compounds for Their Pharmacological Activity. *Biomed Res Int* 2013; 2013: 963248.
- [3] Borges F, Roleira F, Milhazes N, et al. Simple Coumarins and Analogues in Medicinal Chemistry: Occurrence, Synthesis and Biological Activity. *Curr Med Chem* 2005; 12: 887–916.
- [4] Emami S, Dadashpour S. Current developments of coumarin-based anti-cancer agents in medicinal chemistry. *Eur J Med Chem* 2015; 102: 611–630.
- [5] Kumar A, Baccoli R, Fais A, et al. Substitution Effects on the Optoelectronic Properties of Coumarin Derivatives. *Appl Sci*; 10. Epub ahead of print 1 January 2019. DOI: 10.3390/AP10010144.
- [6] dos Santos RR, Turra B, Simon K, et al. Evaluation of genotoxicity and coumarin production in conventional and organic cultivation systems of *Mikania glomerata* Spreng. *J Environ Sci Heal Part B* 2019; 54: 866–874.
- [7] IJSRST, Pankaj S. Borkar, Sangharsh S. Chandekar, et al. International Journal of Scientific Research in Science and Technology. *Int J Sci Res Sci Technol* 2008; 1: 1.
- [8] Lei L, Yang D, Liu Z, et al. Mono-nitration of Coumarins by Nitric Oxide. *Synth Commun* 2004; 34: 985–992.
- [9] Perkin WH. IV.—On some new derivatives of coumarin. *J Chem Soc* 1871; 24: 37–55.
- [10] Clayton A. CXXVIII.—The action of alkalis on certain derivatives of coumarin. *J Chem Soc, Trans* 1910; 97: 1388–1408.
- [11] Kumar, P. Sudhir; Ghosh, G.; Rout, S. K.; Paul D. Synthesis and antimicrobial evaluation of some novel 4-hydroxy coumarin derivatives bearing azo moiety. *Rasayan J Chem* 2013; 6: 147–152.
- [12] Singh I, Kaur H, Kumar S, et al. Synthesis of New Coumarin Derivatives as Antibacterial Agents. *Int J ChemTech Res CODEN(USA)*; 2: 1745–1752.
- [13] Regal MKA, Shaban SS, El-Metwally SA. Synthesis and Antimicrobial Activity of Some New Coumarin and Dicoumarol Derivatives. *Russ J Bioorganic Chem* 2020; 46: 438–447.
- [14] Kudale SD, Deodhar MN. Synthesis and evaluation of some coumarin containing potential antimicrobial agents. *E-Journal Chem* 2012; 9: 2493–2500.
- [15] Dekić BR, Radulović NS, Dekić VS, et al. Synthesis and antimicrobial activity of new 4-heteroaryl amino coumarin derivatives containing nitrogen and sulfur as heteroatoms. *Molecules* 2010; 15: 2246–2256.
- [16] Naik CG, Malik GM, Parekh HM. Novel coumarin derivatives: Synthesis, characterization and antimicrobial activity. *South African J Chem* 2019; 72: 248–252.
- [17] Al-Haiza MA, Mostafa MS, El-Kady MY. Synthesis and biological evaluation of some new coumarin derivatives. *Molecules* 2003; 8: 275–286.
- [18] Kulkarni A, Patil SA, Badami PS. Synthesis, characterization, DNA cleavage and in vitro antimicrobial studies of La(III), Th(IV) and VO(IV) complexes with Schiff bases of coumarin derivatives. *Eur J Med Chem* 2009; 44: 2904–2912.
- [19] Rehman S, Ikram M, Baker RJ, et al. Synthesis, characterization, in vitro antimicrobial, and U2OS tumoricidal activities of different coumarin derivatives.

- Chem Cent J* 2013; 7: 68.
- [20] Arshad A, Osman H, Bagley MC, et al. Synthesis and antimicrobial properties of some new thiazolyl coumarin derivatives. *Eur J Med Chem* 2011; 46: 3788–3794.
- [21] Sahoo SS, Shukla S, Nandy S, et al. Synthesis of novel coumarin derivatives and its biological evaluations. *Eur J Exp Biol* 2012; 2: 899–908.
- [22] Abduljabbar TT, Hadi MK. Synthesis, Characterization and Antibacterial Evaluation of Some Coumarin Derivatives. *Iraqi J Pharm Sci* 2021; 30: 249–257.
- [23] Betti N, Shia JS, Kadhum AAH, et al. Harnessing coumarin chemistry: Antibacterial, antifungal, and antioxidant profiling of novel coumarin derivatives. *J Med Pharm Chem Res* 2024; 6: 1530–1546.
- [24] Wili P. Coumarin – Dithiocarbamate Derivatives as Biological Agents. 2025; 1–15.
- [25] Reddy DS, Kongot M, Netalkar SP, et al. Synthesis and evaluation of novel coumarin-oxime ethers as potential anti-tubercular agents: Their DNA cleavage ability and BSA interaction study. *Eur J Med Chem* 2018; 150: 864–875.
- [26] Phutdhawong W, Chuenchid A, Taechowisan T, et al. Synthesis and Biological Activity Evaluation of Coumarin-3-. *Molecules* 2021; 26: 1–12.
- [27] Al-Hazmy SM, Zouaghi MO, Al-Johani JN, et al. Chemosensing Properties of Coumarin Derivatives: Promising Agents with Diverse Pharmacological Properties, Docking and DFT Investigation. *Molecules* 2022; 27: 1–31.
- [28] Quadri-Spinelli T, Heilmann J, Rali T, et al. Bioactive coumarin derivatives from the fern *Cyclosorus interruptus*. *Planta Med* 2000; 66: 728–733.
- [29] Valadbeigi E, Ghodsi S. Synthesis and Characterization of Some New Thiazolidinedione Derivatives Containing a Coumarin Moiety for their Antibacterial and Antifungal Activities. *Med Chem (Los Angeles)* 2017; 07: 178–185.
- [30] Abd-El-Aziz AS, El-Agrody AM, Bedair AH, et al. Synthesis of hydroxyquinoline derivatives, amino-hydroxychromene, aminocoumarin and their anti-bacterial activities. *Heterocycles* 2004; 63: 1793–1812.
- [31] Tataringa G, Stan C, Mircea C, et al. Antioxidant evaluation of some coumarin derivatives. *Farmacia* 2016; 64: 533–538.
- [32] Špirtović-Halilović S, Veljović E, Salihović M, et al. Synthesis, microbiological activity and in Silico investigation for some synthesized coumarin derivatives. *Croat Chem Acta* 2020; 93: 1–9.
- [33] Tandel P, Khalifa Z, Upadhyay R, et al. Investigation of recent advancement in the pharmacological potential of C-3 substituted coumarin derivatives against *S. aureus*. *Discov Chem*; 2. Epub ahead of print 2025. DOI: 10.1007/s44371-025-00134-x.
- [34] Imran M, Khan SA. Synthesis and Antimicrobial Activity of Some 2-Amino-4-(7- Substituted / Unsubstituted Coumarin-3-yl) -6- (Chlorosubstitutedphenyl) Pyrimidines. 2015; 14: 1265–1272.
- [35] Ahmed R, Al-Shuaeeb A. Synthesis of new coumarin derivatives containing aminobenzotriazole, triazole moieties and their antimicrobial activities. *J Med Sci* 2023; 1: 1.
- [36] Benci K, Mandić L, Suhina T, et al. Novel coumarin derivatives containing 1,2,4-triazole, 4,5-dicyanoimidazole and purine moieties: Synthesis and evaluation of their cytostatic activity. *Molecules* 2012; 17: 11010–11025.