



Imperative Advances on Antimicrobial Activity of Coumarin Derivatives

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ABSTRACT

Emergence of resistance by bacterial and fungal stains towards existing antimicrobial agents is one of the major problem as well as motivation to synthesize a new class of antimicrobial agents possessing potent activity compared to commonly used therapy. Coumarin is the heterocyclic compound formed from benzene and pyrone ring containing oxygen and its derivatives are of wide awareness because of their diverse biological activity and clinical applications, they are remarkably effective compounds both with respect to their inhibitory activity and their favourable selectivity ratio. Coumarins are regarded as a promising class of bioactive heterocyclic compounds that exhibit a range of biological activities like anti-microbial, anti-viral, anti-diabetic, anti-cancer activity, anti-oxidant, anti-parasitic, anti-helminthic, anti-proliferative, anti-convulsant, anti-inflammatory and anti-hypertensive activities etc. The information given in this manuscript may be helpful in the further research of better antimicrobial agents having lesser microbial resistance and improved antimicrobial profile.

Keywords: Coumarin, anti-fungal, anti-bacterial activities.

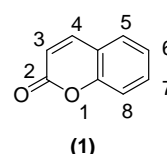
INTRODUCTION

Microbial infections are defined as an invasion of microbes including bacteria and fungi which are able to reproduce in the body can cause acute, chronic or latent infections depending upon duration of infections. Antimicrobial resistance (AMR) is resistance of a microorganism to an antimicrobial medicine to which it was previously sensitive. Resistant organisms like bacteria and fungi are able to withstand attack by antimicrobial medicines, such as antibiotics so that standard treatments become ineffective and infections persist and may spread to others¹. AMR is a consequence of misuse of antimicrobial medicines and develops when a microorganism mutates or acquires a resistance gene. About 440000 new cases of multidrug-resistant tuberculosis (MDR-TB) emerge annually causing at least 150000 deaths. Extensively drug-resistant tuberculosis (XDR-TB) has been reported in 64 countries to date².

A high percentage of hospital-acquired infections are caused by highly resistant bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci. Ciprofloxacin is the only antibiotic currently recommended by world health organization (WHO) for the management of bloody diarrhoea due to Shigella organisms, now that widespread resistance has developed to other previously effective antibiotics³. But rapidly increasing prevalence of resistance to ciprofloxacin is reducing the options for safe and efficacious treatment of shigellosis, particularly for children. New antibiotics suitable for oral use are badly needed. New resistance mechanisms, such as the β -lactamase NDM-1, have emerged among several gram-negative bacilli. This can render powerful antibiotics,

which are often the last defence against multi-resistant strains of bacteria, ineffective⁴.

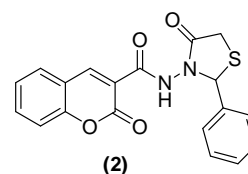
Heterocyclic compounds play an important role as medicinal agents by providing pharmacophores and coumarin is one such heterocyclic scaffold. Coumarin is made up of benzene and pyrone rings containing oxygen (**1**) having molecular formula $C_9H_6O_2$. It is incorporated in wide variety of medicinal agents such as antibacterial, antifungal, anti-inflammatory, anticancer and antiviral agents etc⁵.



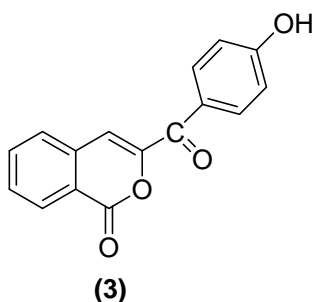
ANTIMICROBIAL ACTIVITIES

Coumarin derivatives are having promising antimicrobial activities as per recent literature survey, details of which have been presented as given below:

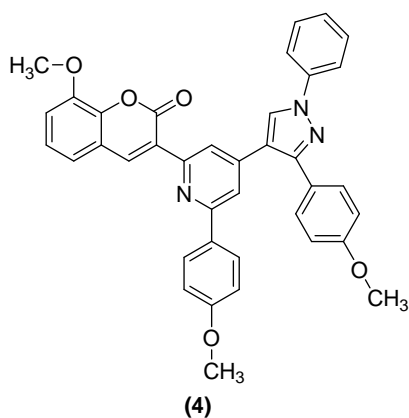
Rama Ganesh *et al.* synthesized some coumarin derivatives containing thiazolidin-4-one ring (**2**) and were screened for their antibacterial activity against Gram-positive bacteria *Staphylococcus aureus*, *Bacillus subtilis* and Gram-negative bacteria *Klebsiella pneumoniae*, *Escherichia coli* at the concentration of 0.001 mol/ml compared with standard drug Ciprofloxacin. Zone of inhibition of highly active compound was 20 mm against *Staphylococcus aureus* and *Bacillus subtilis*⁶.



Purohit *et al.* reported synthesis and biological activities of some substituted 3-(4-hydroxybenzoyl)-1*H*-isochromen-1-one (**3**), 2-benzopyran 1*H*-2-one, 1*H*-2-oxo-benzopyran-3-carboxylic acids and 2-benzofuran-1*H*-one. All the compounds showed good activity against *Staphylococcus aureus* and *Escherichia coli*⁷.

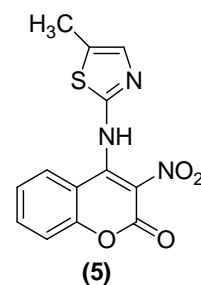


Brahmbhatt *et al.* synthesized 4-methyl-3-phenyl-6-[4-(3-aryl-1-phenyl-1*H*-pyrazol-4-yl)-6-aryl-pyridin-2-yl] coumarin derivatives (**4**) and were screened for their anti-bacterial activity against *Escherichia coli* (Gram negative bacteria), *Bacillus subtilis* (Gram positive bacteria) and anti-fungal activity against *Candida albicans* by agar cup diffusion method. DMF was used as blank, Streptomycin was used as anti-bacterial standard and Clotrimazole was used as anti-fungal standard drug at concentration of 1000µg/ml. All the synthesized compounds showed activity against both gram positive and gram negative bacteria but lesser activity compared to standard drug⁸.

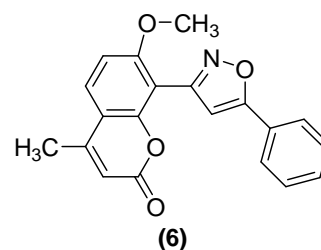


Dekic *et al.* synthesized new 4-heteroarylamino coumarin derivatives containing nitrogen and sulfur (**5**) were tested for their *in-vitro* antimicrobial activity, in a standard disk diffusion assay, against thirteen strains of bacteria; six Gram-positive used were: *Bacillus subtilis* (ATCC 6633), *Clostridium pyogenes* (ATCC 19404), *Enterococcus* sp. (ATCC 25212), *Micrococcus flavus* (ATCC 10240), *Sarcina lutea* (ATCC 9341) and *Staphylococcus aureus* (ATCC 6538) and seven Gram-negative bacteria utilized in the assays were: *Klebsiella pneumoniae* (ATCC 10031), *Proteus vulgaris* (ATCC 8427), *Escherichia coli* (ATCC 8739), *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27857), *Pseudomonas aeruginosa* (ATCC 9027) and *Salmonella enteritidis* (ATCC 13076) and three fungal strains *Aspergillus niger* (ATCC 16404), *Candida albicans* (ATCC 10231) and *Saccharomyces cerevisiae* (ATCC 9763). One compound was found to be

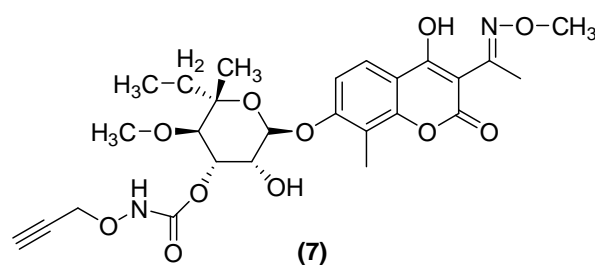
the most active compound which showed reduction of bacterial and fungal growth comparable with the standards drugs like tetracycline and nystatine⁹.



A new series of 7-methoxy-4-methyl-8-[5-(substituted aryl)isoxazol-3-yl]-2*H*-benzopyran-2-ones (**6**) were synthesized by Sandeep *et al.* Antimicrobial activity was carried out against 24 hr old cultures of *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Bacillus subtilis*. The fungi used were *Aspergillus niger*, *Aspergillus flavus* and *Candida albicans*. The compounds were tested at concentrations of 25 µg/ml in dimethylformamide against all the organisms. Ciprofloxacin (25 µg/ml) and fluconazole (25 µg/ml) were used as standard drugs for anti bacterial and antifungal activities respectively. Among the compounds tested for anti bacterial activity, one compound showed highest zone of inhibition against *S. aureus* and *B. subtilis* and minimum inhibition against *E. coli* and *P. aeruginosa*. The remaining compounds exhibited moderate activity¹⁰.

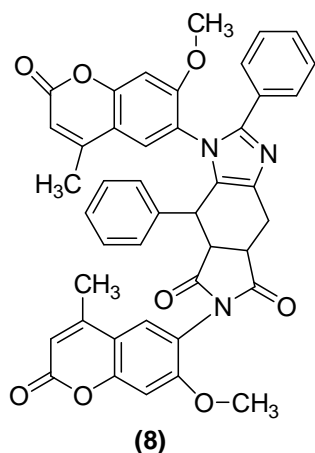


A new series of coumarin inhibitors of DNA gyrase B bearing a *N*-propargyloxycarbamate at C-3' of various 5',5'-di-alkylribose including RU79115 (**7**) were synthesised and their antibacterial activities were delineated by Musicki *et al.* *In-vitro*, RU79115 bactericidal activity against *E. faecium* and *S. aureus* was time dependent and similar to that of standard drug vancomycin in the case of *S. aureus*¹¹.

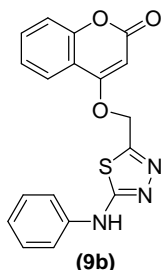
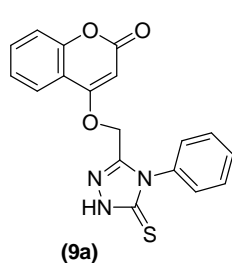


A novel series of 5*H*,7*H*-*N*-(coumarin-6-yl)-2,8-diphenyl-5,7-dioxo-6-(7-methoxy-4-methyl coumarin-6-yl)-4,5,6,7-tetrahydrobenzimidazo[5,6-*c*]pyrrole derivatives (**8**) was synthesized and screened by Choudhari *et al.* for their antibacterial activity against *S. aureus* and *S. typhi* and

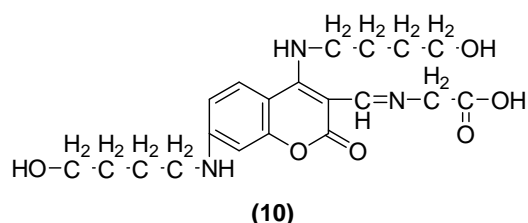
antifungal activity against *A. niger* and *C. albicans*. Ciprofloxacin and miconazole were used as the antibacterial and antifungal standards respectively. All compounds showed antimicrobial activity having MIC (minimum inhibitory concentration) values ranging from 50 µg/ml to 200 µg/ml¹².



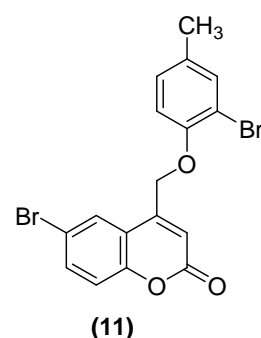
Al-Amiery *et al.* synthesized 4-[(5-mercapto-4-phenyl-4H-1,2,4-triazol-3-yl)-methoxy]-2H-chromen-2-one as coumarin derivatives (**9a-9b**) and antifungal activity was determined based on the growth inhibition rates of the mycelia of strains (*Aspergillus niger* and *Candida albicans*) compared to in Potato Dextrose Broth medium (PDB). Appropriate volumes of tested compounds were added to produce concentrations ranging from 10 to 100 µg/mL. Two compounds showed good activity as antifungals compared to the antifungal ability of fluconazole, which was used as a standard drugs¹³.



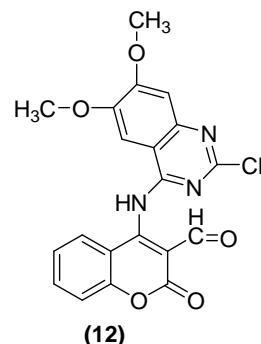
Some novel coumarin derivatives (**10**) were synthesized by Behrami *et al.* The antibacterial activity of synthesized compounds and standard drugs (streptomycin and cefalexine) at concentrations of 2mg/ml, 3mg/ml and 5mg/ml were evaluated against three strains of bacterial culture; *Staphylococcus aureus*, *E. coli* and *Bacillus cereus*. Antibacterial activity of compounds was investigated applying the Kirby-Bayer method. One compound showed a significant antibacterial effect against *S. aureus*, *E. coli* and *B. cereus*¹⁴.



Basanagouda *et al.* synthesized 4-aryloxymethylcoumarins (**11**) and screened for their antibacterial and antifungal activity at different concentrations of 500, 250, 100 and 50 µg/mL by the disc diffusion method. Antibacterial activity was carried out against three Gram-negative bacteria, viz. *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and two Gram-positive bacteria, viz. *Staphylococcus aureus*, and *Streptococcus faecalis*. Ciprofloxacin was used as standard antibacterial drug. Antifungal activity was carried out against five fungi, viz. *Aspergillus flavus*, *Aspergillus fumigatus*, *Candida albicans*, *Penicillium notatum* and *Rhizopus*. Fluconazole was used as standard antifungal drug. In general, the compounds possessing methoxy, chloro, bromo substituents at C-6 position of coumarin showed higher activity compared to the remaining against both Gram-positive and Gram-negative bacteria¹⁵.

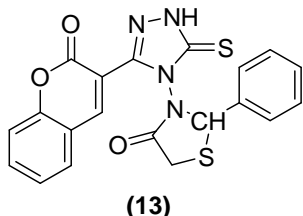


4-Heteroaryl-coumarin-3-carbaldehydes (**12**) were synthesized by Govori *et al.* and antimicrobial properties of these new coumarins were investigated and results were submitted for their activities against *Staphylococcus aureus*, *Escherichia coli*, *Hafnia alvei*, *Pseudomonas aeruginosa* and *Enterobacter cloacae*. The Agar disc diffusion technique measured the diameters of the inhibition zone around discs which were previously wetted with *N, N*-DMF solution of compounds at concentrations of 1, 3 and 5 mg/mL. One compound was more active against *Staphylococcus aureus*, *E. coli* and *Enterobacter cloaco* and not active as antimicrobial agent against *Hafnia alvei* and *Pseudomonas aeruginosa*¹⁶.

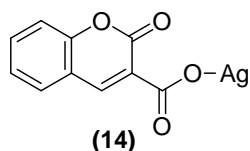


A series of 2-(substituted phenyl)-3-[3-(2-oxo-2H-coumarin-3-yl)-5-thioxo-1,5-dihydro-4H-1,2,4-triazol-4-yl]-1,3-thiazolidin-4-ones (**13**) were synthesized and evaluated by Bhat *et al.* for their antimicrobial activity against Gram positive *S. aureus* and Gram negative *E. coli* stains and antifungal activity against *C. albicans* by cup-

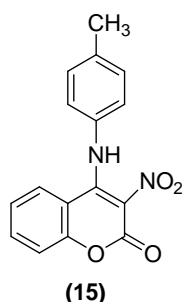
plate method and agar diffusion method. Ciprofloxacin and ketoconazole were used as the standard antibacterial and antifungal drugs respectively. The test compounds and standard drugs were evaluated at concentration of 100 µg/mL. DMF (N, N-dimethylformamide) was used as solvent and control. One compound showed 92% growth inhibition against *S. aureus*, 80% growth inhibition against *E. coli* and 90% growth inhibition against *C. albicans*¹⁷.



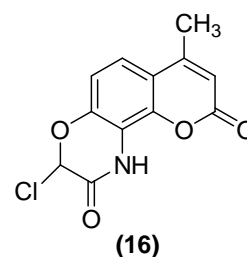
A series of new coumarin-derived carboxylate ligands and their silver (I) complexes (**14**) were synthesized, characterized and screened by Creaven *et al.* for their *in-vitro* antibacterial activity against a range of Gram-positive stains of *S. aureus*, methicillin-resistant *S. aureus*, *S. simulans* and *M. luteus* whilst the Gram-negative strains were *E. coli*, *B. olenius* and *P. agglumerans* as well as for their antifungal activity against a clinical isolate of *Candida albicans*. Whilst none of the ligands showed any antimicrobial activity, a number of the Ag(I) complexes exhibited potent activity. In particular, Ag(I) complexes of hydroxy-substituted coumarin carboxylates demonstrated potent activity against the clinically important methicillin-resistant *Staphylococcus aureus* (MRSA) bacterium (MIC = 0.63 µM)¹⁸.



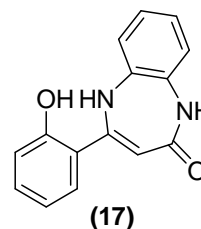
Dekic *et al.* synthesized 4-arylamino-3-nitrocoumarins (**15**) and were evaluated for their *in-vitro* antibacterial and antifungal activities against pathogenic strains including Gram-positive *Staphylococcus aureus* ATCC 6538, *Bacillus cereus*, *Bacillus subtilis* ATCC 6633; Gram-negative *Escherichia coli* ATCC 8739, *E. coli*, *Klebsiella pneumoniae* ATCC 10031, *Salmonella enterica* ATCC 13076 and yeast *Candida albicans* ATCC 10231 and *Aspergillus niger* ATCC 16404. MIC values in µg/ml were determined by taking Tetracycline and Nystatine as the reference drugs. One compound showed the greatest anti-candidal activity as compared with other compounds of the series¹⁹.



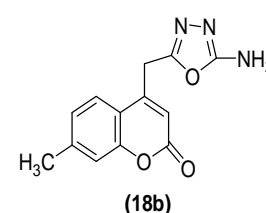
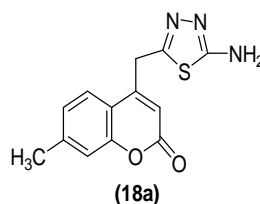
Novel coumarin derivatives (**16**) were synthesised by Sahoo *et al.* and antibacterial activity was conducted against Gram-positive bacteria i.e. *Staphylococcus aureus* and Gram-negative bacteria i.e. *Escherichia coli* by using cup plate method. Each test compound (5 mg) was dissolved in dimethyl sulphoxide (DMSO) (5ml) at a concentration of 1000 µg/ml. All the compounds were tested at a concentration of 0.05 ml (50 µg) and 0.1 ml (100 µg) level and DMSO used as a control. One compound possessed maximum antibacterial activity as compared to standard drug amoxicillin which may be due to presence of chlorine on aromatic ring of coumarins. Other compounds also showed mild to moderate activity at 0.1 ml concentration level on all organisms²⁰.



Hamdi *et al.* synthesized bis[*N*-(4-oxocoumarinylmethylene)]-1,4-diamines (**17**) and the antibacterial activity tests were carried out using *Staphylococcus aureus* ATCC 25923 at a concentration of 10⁶ CFC/ml on the surface of a Mueller-Hinton gelose plate. One compound exhibited the strongest antibacterial activity²¹.

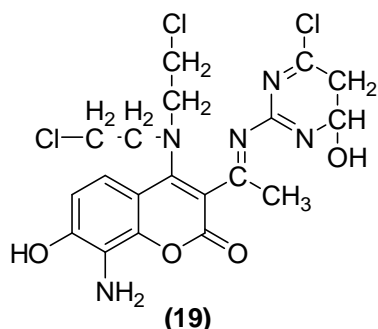


Some novel 4-substituted coumarins (**18a-18b**) were synthesized by Mashelkar *et al.* and subjected to *in-vitro* screening against gram-positive *Staphylococcus aureus* and gram-negative *Salmonella typhi* using tube dilution technique. Ampicillin (MIC = 0.01µg/mL against gram positive *S. aureus*) and trimethoprim (MIC=1µg/mL against gram-negative *S. typhi*) were used as standard drugs. Two compounds showed significant antibacterial activity at concentration levels of 10 to 200 µg/mL against *S. aureus* and *S. typhi*²².

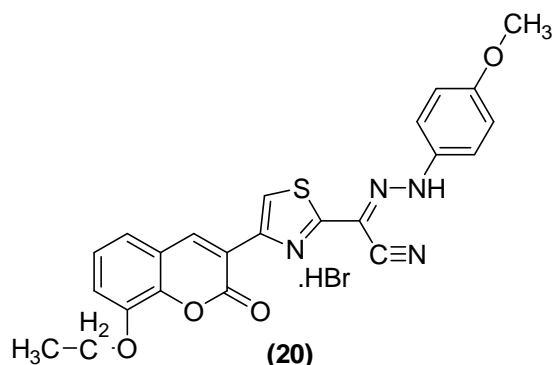


Behrami *et al.* synthesized 8-amino-4,7-dihydroxychromen-2-one coumarin derivatives (**19**). The antibacterial activities of all the compounds and streptomycin and cefalexine at concentrations of

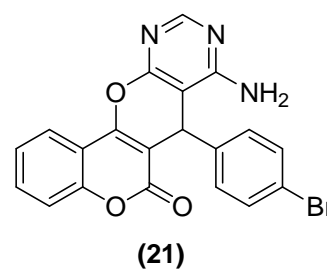
2mg/ml, 3mg/ml and 5mg/ml were studied against gram-positive bacteria (*Staphylococcus aureus* and *Bacillus subtilis*) and gram-negative bacteria (*E. coli*). One compound was more active than cefalexine and lesser active than streptomycin and it was most active among synthesized compounds²³.



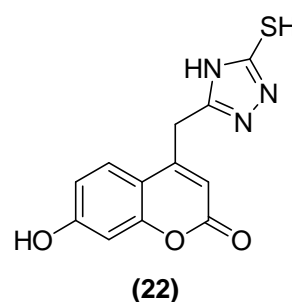
Some novel 8-ethoxycoumarin derivatives (**20**) were synthesized by Mohamed *et al.* and screened for their antimicrobial activities *in-vitro* against two Gram-negative *Bordetella bronchiseptica* (ATCC 4617) and *Escherichia coli* (ATCC 14169) and four Gram-positive *Bacillus pumilus* (ATCC 14884), *Bacillus subtilis* (ATCC 6633), *Staphylococcus aureus* (ATCC 29737) and *Staphylococcus epidermidis* (ATCC 12228) pathogenic bacteria and two fungi *Candida albicans* (ATCC 10231) and *Saccharomyces cerevisia* (ATCC 9080). One compound resulted in wide spectrum antimicrobial activity against all tested bacteria and fungi compared to ampicillin (25 µg/mL) and mycostatin (25 µg/mL) by replacing the hydrogen atom attached to the coumarin nucleus at C-3 with a side chain, while the other compounds with other side chains showed moderate to weak activity²⁴.



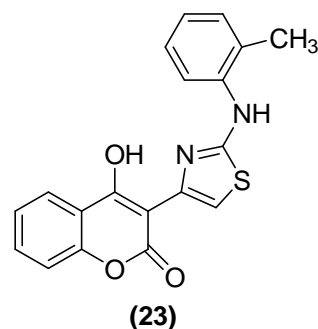
Pyrimidino[5',4'-6,5]-,pyridino[3',2'-6,5] and pyrrolo[3',2'-5,6]4*H*-pyrano-[3,2-c][1]benzopyran-6-one derivatives (**21**) were prepared and screened by Al-Haiza *et al.* for their activity against Gram-positive bacteria (*Staphylococcus aureus*, *Bacillus subtilis*, *Bacillus cereus*), Gram-negative bacteria (*Pseudomonas aeruginosa*, *Escherichia coli*, *Enterobacter aerogenes*), as well as fungi (*Aspergillus niger*, *Penicillium italicum*, *Fusarium oxysporum*). Standard drugs (amoxicillin for bacteria and mycostatin for fungi) were used at a concentration of 1000 ppm for comparisons. One compound exhibited excellent antibacterial activity towards *Enterobacter aerogenes*²⁵.



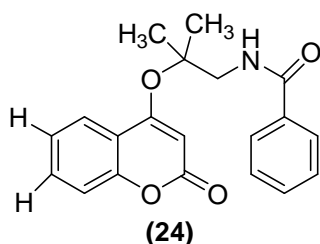
Some derivatives of (7-hydroxy-2-oxo-2*H*-chromen-4-yl)-acetic acid hydrazide (**22**) were synthesized by Cacic *et al.* and were found to possess high antimicrobial activity against *Staphylococcus pneumoniae* and were slightly less active against *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Bacillus cereus*, and *Salmonella panama* as compared to standard drug²⁶.



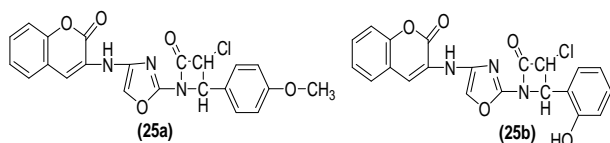
Novel 4-hydroxy-chromene-2-one derivatives (**23**) were synthesized by Mladenovic *et al.* and screened for their antibacterial activity against Gram-positive bacteria *Staphylococcus aureus*, *Bacillus subtilis* and Gram-negative bacteria *Klebsiella pneumoniae*, *Escherichia coli* and their antifungal activity against *M. mucedo*, *C. albicans*. Streptomycin was used as standard anti-bacterial drug and ketoconazole was used as standard anti-fungal drug. One compound had activity equal to that of standard drug ketoconazole (31.25 µg/mL) against *M. mucedo*²⁷.



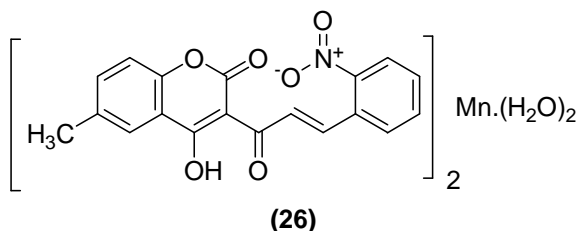
Acyl coumarins, 4-hydroxy-, and 7-hydroxycoumarins and coumaric amide dimers (**24**) were synthesized by Lin *et al.* and were tested against stains of *Bacillus subtilis* (BCRC 10029), *Staphylococcus aureus* (BCRC 11863), *Escherichia coli* (BCRC 11758), and *Pseudomonas aeruginosa* (BCRC 11733) and Penicillin G potassium salt (CAS 113-98-4, USP grade) was used as a reference drug. One compound was the most potent compound out of the tested compounds against *B. subtilis* with MIC value of 8 µg/mL²⁸.



A novel series of 3-[(2'-Substituted benzylidene amino thiazol-4'-yl) amino] coumarins (**25a-25b**) was prepared by Singh *et al.* and evaluated for antibacterial activity against various bacteria, *Staphylococcus aureus* 209 P, *E. Coli* ESS 2231, *Proteus vulgaris*, *K. Pneumoniae* were used and antifungal activity was performed against *Candida albicans* ATCC 10231 and results were compared with gatifloxacin and ciprofloxacin for antibacterial and fluconazole for antifungal activities respectively and propylene glycol treated group served as control. One compound showed potent antibacterial activity while the other compound exhibited most potent antifungal activity²⁹.

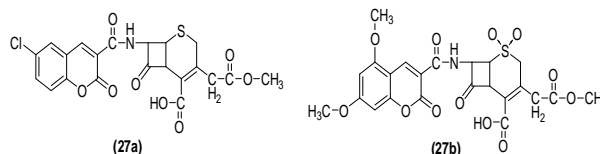


Some novel 3-[(3-(2'-Nitrophenyl)-prop-2-enoyl]-4-hydroxy-6-methyl-2H-chromene-2-ones (**26**) were synthesized by Vyas *et al.* *In-vitro* antimicrobial activity of all synthesized compounds and standard drugs were evaluated against four strains of bacteria which included two Gram-positive bacteria such as *Staphylococcus aureus*, *Bacillus megaterium* and two Gram-negative bacteria such as *Escherichia coli*, *Proteus vulgaris* and one fungi *Aspergillus niger*. Zone of inhibition of highly active compound was 25 mm as antibacterial agent against *E. coli* compared with standards ampicillin (16mm), amoxicillin (17mm), ciprofloxacin (26mm), erythromycin (22mm) and was 23 mm as antifungal agent against *A. niger* compared with standard drug griseofulvin (21mm)³⁰.

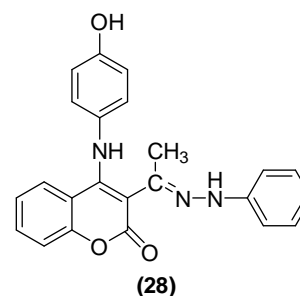


A novel series of coumarin 7-substituted cephalosporins and sulfones (**27a-27b**) was synthesized by Bonsignore *et al.* and tested against *Staphylococcus aureus* (ATCC 25923), *Escherichia coli* (ATCC 25922) and *Pseudomonas aeruginosa* (ATCC 27853) with varying concentrations of the associated antibiotic cefotaxime (0.125-256 µg/ml) against an extended spectrum of β-lactamase-producing *K. pneumoniae*, or ampicillin (0.125-256 µg/ml) against a penicillinase-producing strain of *S. aureus*. Cephalosporins

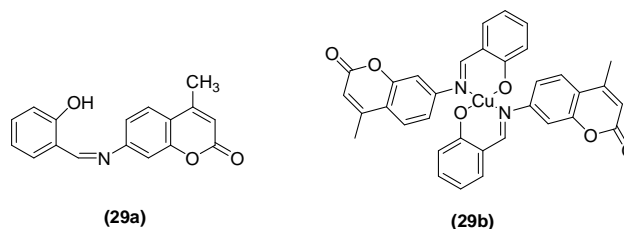
showed a potential activity against Gram-positive microorganisms and sulfones showed no significant activity, neither as antimicrobial agents nor as inhibitors of β-lactamase. An association of sulfone with ampicillin was observed to inhibit Gram-positive microorganisms with a lower MIC value than for ampicillin alone³¹.



Vaso *et al.* reported the organic synthesis of some new 2H-[1]-benzopyran-2-one (coumarin) derivatives (**28**) at concentrations of 2 mg/mL, 3 mg/mL and 5 mg/mL and screened for the *in-vitro* test of its antibacterial activity against three bacterial cultures: Gram positive bacteria i.e. *Staphylococcus aureus* and *Bacillus aureus* and Gram negative bacteria i.e. *Escherichia coli* was compared to the standard antibiotics Cephalexine and Streptomycine. One compound was weaker than that of Streptomycine and stronger as compared to Cephalexine in antibacterial activity against *Staphylococcus aureus*³².

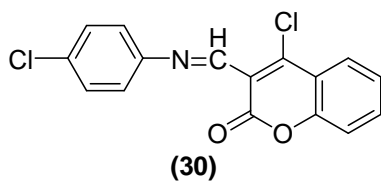


Creaven *et al.* yielded a series of Schiff bases and Cu(II) complexes (**29a-29b**). All of the free ligands and their metal complexes were tested for their antifungal activity compared to that of the commercially available antifungal drugs, ketoconazole and amphotericin B. The ligands showed no antimicrobial activity whereas a number of the metal complexes exhibited potent antimicrobial activity when compared with their respective standard drugs³³.

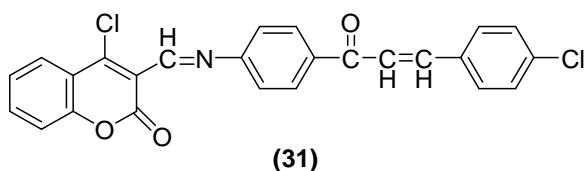


Bairagi *et al.* yielded a series of the title compounds 4-chloro-3-((substituted-phenylimino) methyl)-2H-chromen-2-ones (**30**) and evaluated for antimicrobial activity *in-vitro* against gram positive *Staphylococcus aureus* (ATCC 29737) and *B. subtilis* (ATCC 2063) and gram negative bacteria *E. coli* (ATCC 20931) and fungi *Aspergillus niger* (ATCC 16404) and *Candida albicans* (ATCC 10231). One compound was found to be most active with an MIC of 15 µg /mL against all the tested

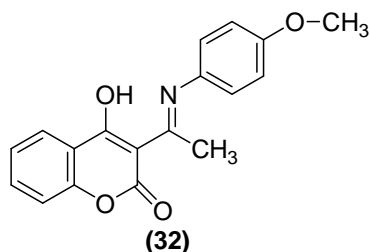
organisms. Amoxicillin was standard for antibacterial activity and fluconazole for antifungal activity³⁴.



A series of the Schiff's bases, 3-(4-(4-(substituted phenyl)prop-1-ene-3-one) phenylimino) methyl)- 4-chloro-2h-chromen-2-ones (**31**) were synthesized by Kudale *et al.* and were evaluated for antimicrobial activity *in-vitro* against gram positive bacteria: *S. aureus* (ATCC 9144), *B. subtilis* (ATCC 6633) and *S. epidermis* (ATCC 12228) and gram negative bacteria: *E. coli* (ATCC 25922), *S. typhi* and *P. aeruginosa* (ATCC 9027) and the antifungal activity was evaluated against *A. niger* (ATCC 10594) and *C. albicans* (ATCC 10231) using amoxicillin and fluconazole as standard drugs for antibacterial and antifungal activities respectively. One compound was found to be most active with an MIC of 20 µg/mL against all the tested organisms³⁵.



4-hydroxy-3-(1-(arylimino)ethyl)chromen-2-one derivatives (**32**) were synthesized by Girgaonkar *et al.* and *in-vitro* biological screening against the bacterial species, two gram- negative cultures viz. *Escherichia coli*, *Salmonella typhi* and two Gram-positive cultures viz. *Staphylococcus aureu*, *Bacillus subtilis* and *Aspergillus niger*, *Penicillium chrysogenum*, *Fusarium moneliforme*, *Aspergillus flavus* were selected as test fungal cultures. Penicillin and Gresiofulvin were used as standards. All imines showed lesser activity against *E. coli*, *S. aureus* and *B. subtilis* compared with penicillin taken as standard drug. Antimicrobial activities of some compounds were higher in comparison with respective standard drugs³⁶.



CONCLUSION

Coumarin derivatives are known to be medicinally important by having different pharmacological activities including antimicrobial activity as per the recent most literature compiled in this manuscript. This review provides overview of antimicrobial potential of coumarin derivatives and therefore it may be conclude that these derivatives may serve as valuable source of lead

compounds for the drug design and development of effective antimicrobial therapy.

Declaration of source of support and conflict of interest

We hereby declare that there is neither any source of support nor conflict of interest associated with this manuscript.

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