Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(5):944-946

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Antimicrobial structure-efficacy relationship of sugar fatty acid esters

Lou Xin

Material and Chemical Engineering College, Chuzhou University, Chuzhou, Anhui Province, P. R. China

---

ABSTRACT

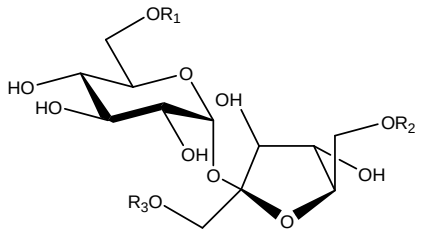
Carbohydrate fatty acid esters are biodegradable, nontoxic and nonionic surfactants, their antimicrobial activity is herein reviewed. The regioselective synthesis of sugar esters with enzymatic and chemical method, especially tin-mediated method, is well described. The antimicrobial activity of these sugar esters, especially how carbohydrate hydrophilic cores, the length of fatty acid chain and the glycoconjugate linkage of sugar fatty acid esters affect their antimicrobial activity is described in detail.

Keywords: carbohydrate fatty acid esters, antimicrobial, structure-efficacy

---

INTRODUCTION

Polyglycerol esters of fatty acids (PGEs) have been reported to have antibacterial activity, particularly against gram-positive bacteria [1]. Among the first fatty acid esters of sugars reported to display antimicrobial activity were sucrose dicaprylate and sucrose monolaurate, which were shown to be active against some gram-negative and gram-positive bacteria, as well as fungi [2, 3]. Fatty acid esters of sucrose have also been reported to inhibit the growth of *Vibrio parahaemolyticus* [4]. It is important to note that the fatty acid esters of sucrose tested against *Vibrio parahaemolyticus* were not pure compounds and consisted of a mixture of mono-, di- and tri-esters (see Fig. 1) Moreover, the ratio of mono-, to di- and tri-ester varied considerably among the tested compounds.



R_1, R_2, R_3 = H,octanoyl,decanoyl, lauroyl,myristoyl, palmitoyl

Fig 1 Structure of fatty acid esters of sucrose (mono-, di- and triester)

Similar sucrose esters were reported as effective inhibitors of *Bacillus stearothermophilus, Bacillus coagulans, Desulfotomaculm nigrificans,* and some typical anaerobic spore forming bacteria including *Clostridi* [5]. The experiments showed that as little as 200 µg/ml of sucrose palmitate could prevent the spoilage of canned milk coffee.

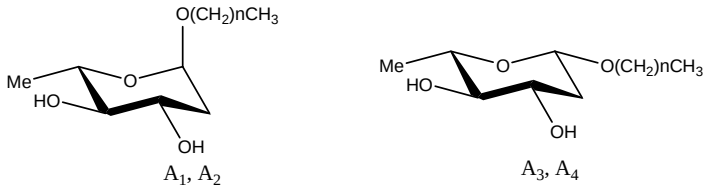
The application of the antimicrobial activity of sucrose esters has been extended. It has been demonstrated that commercial sucrose fatty acid esters can decrease acid production from sugar by oral bacteria [6] and also reduce the development of dental caries in rats when added to sucrose-rich diets [7]. Use of fatty acids and their sugar esters potentially represents a non-toxic and non-allergenic means of controlling the acidogenic organisms associated with dental caries.

Synergism effect of sucrose fatty acid esters was also observed, when sucrose palmitate(P1570) and sucrose stearate(P1670) were added into nisin, a synergist enhancement of the bacteriostatic activity of nisin against some gram-positive bacteria as strains of *L. monocytogenes, Bacillus cereus, Lactobacillus Plantarum* and *Staphylococcus aureus* was noticed, however, the combination of nisin with sucrose fatty acid esters showed no inhibition against gram-negative bacteria [8] .

The elucidation of structure-efficiency relationship of sugar fatty acid esters needs the synthesis of an abundance of sugar esters with varying structure, while sugar esters could be synthesized chemically and enzymatically by transesterification and direct esterification. Since lipase was found to catalyze esterification reaction in organic solvent [9], enzymatic synthesis of novel sugar fatty acid esters has been widely employed and can be highly regioselective [10-14]. Watanabe ever synthesized 23 carbohydrate monoesters with enzyme method, and found that galactose and fructose laurates showed the greatest growth-inhibitory effect against *Streptococcus mutans*, while other analogues of hexose laurates showed no antibacterial activity, indicating that configuration of the hydroxyl group in the carbohydrate moiety of carbohydrate esters markedly affects the antibacterial activity [15].

Kumari and Devulapalle [16] also used this enzyme method to regioselectively synthesize a series of fatty acid esters of sucrose, maltose and maltriose for use as inhibitors of the glucosyltransferases of *Streptococcus sobrinus*. The results showed that lauroyl esters completely inhibit the growth of *Streptococcus sobrinus* at concentrations in the range of 500-2000 μg/ml in liquid media, indicating that the chain length of fatty acid markedly affect the antibacterial activity. These non-toxic derivatives appear very promising for inclusion in oral-hygiene products aimed at disrupting plaque formation and preventing dental caries,

More recently, Rauter *et al* [17] synthesized a series of alkyl 2,6-dideoxy-L- arabino-hexopyranosides (Fig. 2)and evaluated the antibacterial and antifungal activities of these surface-active glycosides using a paper disk diffusion method.



A_1, n = 12: Dodecyl α-L-2,6-dideoxy-L-arabino-hexopyranoside
A_2, n = 7: Octyl α-L-2,6-dideoxy-L-arabino-hexopyranoside
A_3, n = 12: Dodecyl β-L-2,6-dideoxy-L-arabino-hexopyranoside
A_4, n = 7: Octyl β-L-2,6-dideoxy-L-arabino-hexopyranoside

Fig.2 The structure of alkyl 2,6-dideoxyl-L-arabino-hexopyranosides

The investigation of the relationships between surfactant structure and antibacterial activity showed that both the length and orientation of alkyl chain affect antibacterial activity. Dodecyl α-L-2,6-dideoxy-L-arabino-hexopyranoside (C12) had a higher activity against *Bacillus cereus* and *Bacillus subtilis* than against *Enterococcus faecalis* and *Listeria monocytogenes*. In regard to the octyl α-L-glycoside (C8), some inhibition of the growth of *Bacillus cereus, Bacillus subtilis, Enterococcus faecalis, Listeria monocytogenes* and *Staphyloco ccus aureus* was observed as well.

Tin-mediated method has been proved by our research work to be one of effective chemical method to regioselectively synthesize sugar fatty acid esters, with this method series of fatty acid esters of methyl α-D-glucopyranoside [18], methyl β-D-galactopyranoside [19], lactose [20], methyl α-D glucuronic acid and azide α-D glucuronic acid [21] were synthesized, the initial screening of these glycoside fatty acid esters as antimicrobial agents was also conducted, the results of our antibacterial tests indicated that both the length of fatty acid chain and carbohydrate moiety markedly affect the antibacterial activity ,especially against some gram-positive bacterial.

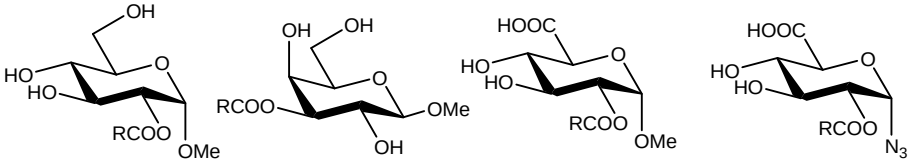


Fig. 3 glycoside fatty acid derivatives investigated as antimicrobial agent
R= octanoyl, decanoyl, lauoryl, myristoyl,palmitoyl, stearoyl;

Julie *et al* [22] designed chemical syntheses to investigate the effects of carbohydrate versus non-carbohydrate hydrophilic cores, the number of fatty acids attached to the hydrophilic core, the glycoconjugate linkage and the length of fatty acid chain on antimicrobial activity, this work provide some insights into structure /activity relationships for these compounds, the analysis of both ester and ether fatty acid derivatives of the same carbohydrate, in tandem with alpha and beta configuration of the carbohydrate moiety suggest that the carbohydrate moiety is involved in the antimicrobial activity of the fatty acid derivatives and that the nature of the bond also has a significant effect on efficacy [23] .

In their further work [24] the antimicrobial activity and mode of action of novel carbohydrate fatty acid (CFA) derivatives against *Staphylococcus aureus* were investigated. Cell-membrane permeabilization was associated with CFA treatment and may account for at least a component of the mode of action of these compounds. This study is the first work providing insights into the mode of antibacterial action.

Effects of sugar fatty acid esters on biofilm formation by food-borne pathogenic bacteria were investigated, Sugar fatty acid esters with long chain fatty acid residues (C14-16) inhibited biofilm formation by *Streptococcus mutans* and *Listeria monocytogenes* at 0.01% (w/w), but bacterial growth was not affected at this low concentration [25].

Long chained alkyl oligosaccharides were also found to show anti-HIV activities, especially sulfated alkyl oligosacharides composed of 5-11 glucose residues and alkyl groups ranging from 10 to 18 at the reducing-terminal carbon atoms showed high anti-HIV activities, the sulfated alkyl oligosaccharides that have long alkyl groups at the reducing end exhibited tens to hundreds times higher anti-HIV activities than those of the corresponding sulfated oligosaccharides without alkyl groups [26]. The increase in activity may be attributable to formation of the same type of structure as that of surface-active agents.

Acknowledgment
This work was supported by Anhui Provincial-level University Research Projects Funding KJ2014A136.

REFERENCES

[1] AJ Conlay; JJ Kabara, *Antimicrob. Agents Chemother*., **1973**, 4(5), 501-506.
[2] N Kato; IJ Shibasaki, *Antibact. Antifung. Agents*, **1975**, 3, 355-360.
[3] N Kato; IJ Shibasaki, *Ferment. Technol*., **1975**, 53, 793-801.
[4] LR Beuchat, *Appl. Environ. Microbiol*., **1980**, 39, 1178–1182.
[5] N Suwa; HJ Michida, *Jpn. Soc. Food Sci. Technol*., **1988**, 35(10), 706-708.
[6] Y Iwami; CF Schachtele; T Yamada, *J. Dent. Res*., **1995**, 74, 1613–1617.
[7] KA Williams; BR Schemehorn; JL MacDonald; GK Stookey; S Katz, *Arch. Oral. Biol*., **1982**, 27, 1027–1031.
[8] LV Thomas; EA Davies, *J. Appl. Microbiol*., **1998**, 85(6), 1013-1022.
[9] M Therisod; AM Klibanov, *J. Am. Chem. Soc*., **1986**, 108, 5638-5640.
[10] LQ Cao; UT Bornscheuer; RD Schmid, *Biocatal. Biotransfor*., **1998**, 4, 249-257.
[11] FJ Plou; MA Cruces; M Ferrer; G Fuentes, *J. Biotechnol*., **2002**, 1, 55-66.
[12] VanDen Broek; LA Boeriu, *Carbohydr. Polym*., **2013**, 1, 65-72.
[13] P Adlercreutz, *Chem. Soc. Rev*., **2013**, 15, 6406-6436.
[14] M Ferrer; FJ Plou; M Bernabe, *Tetrahedron*, **2000**, 24, 4053-4061.
[15] T Watanabe; S Katayama, *Curr. Microbiol*., **2000**, 41(3), 210-213.
[16] S Kumari; D Devulapalle, *Carbohydr. Res.*, **2004**, 339(6),1029-1034.
[17] A Rauter; S Lucas; T Almeida, *Carbohy. Res*., **2005**, 340, 191-201.
[18] X Lou; J O'Brien; G Henehan; S Cassidy, *Asian J. Chem*., 2010, 22(4), 3135- 3146.
[19] X Lou; J Zhao, *Chin. Chem. Soc*., **2012**, 59,1111-1118.
[20] X Lou; XT Ge; J Zhao; S Cassidy, *Asian J. Chem*., **2011**, 23(8), 3667- 3669.
[21] X Lou; S Cassidy, *Sci. China Chemistry*, **2010**, 53(4), 877-883.
[22] A Smith; P Nobmann; J Dunne, *Carbohy. Res*., **2008**, 343, 2557-2566.
[23] P Nobmann; A Smith; J Dunne; G Henehan; P Bourke, Int. J. Food Microbiol. **2009**, 128(3),440-445.
[24] P Nobmann; G Henehan, J. Appl. Microbiol., **2010**, 108(6), 2152-2161.
[25] S Furukawa; Y Morinaga, Int. J. Food Microbiol., **2010**, 138, 176-180.
[26] K Katsuraya; N Ikushima; N Takahashi, Carbohydr. Res., **1994**, 260(1), 51-61.