COMMENTARY

GROWTH-INHIBITORY EFFECT OF ANTIBACTERIAL SELF-ETCHING PRIMER ON MUTANS STREPTOCOCCI OBTAINED FROM ARRESTED CARIOUS LESIONS

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This research article nicely demonstrates that an adhesive primer containing a methacrylate derivative of dodecylpyridinium bromide (MDPB) can have bactericidal activity on contaminated dentin from arrested carious lesions. This antibacterial monomer has been under development by Kuraray since 1993. Attempts to make resin composites with antiplaque properties using the same monomer in the matrix have been less successful because 80% of the surface of the composite is composed of filler particles, not resin matrix.[1,2] Recently, Imazato and colleagues have been able to increase the MDPB concentration in resin composites to the point where they do exhibit antibacterial properties.[3] The problem with incorporating MDPB into polymerized comonomer blends is that much of the MDPB becomes covered by dimethacrylate, 2-hydroxyethyl methacrylate, and other comonomers, resulting in a low surface density of dodecylpyridinium bromide groups. This is not a problem when MDPB is used as a primer in the liquid state. Under liquid conditions, the pyridinium group of MDPB is bactericidal until it is immobilized by polymerization.

This dental research is but one example of a growing revolution in the development and incorporation of antimicrobial chemical groups that can be covalently coupled to plastics, ceramics, paper, and textiles. In some of these applications, the antimicrobial groups are covalently linked only to the surface, after the material has been cast, molded, or spun. Such treatment results in a monomolecular layer of antibacterial functional groups on the surface that should last for the lifetime of the product. Most of the treatments are based on polyamides that are highly cationic. Early examples of cationic compounds were benzalkonium chloride and chlorhexidine. However, these were soluble in aqueous solutions, which meant their concentrations could be diluted to levels below therapeutic. Benzalkonium chloride is a mixture of alkylbenzyl dimethylammonium chlorides in which the alkyls are long-chain (C_8-C_{18}) compounds that can penetrate bacterial cell walls and disrupt their lipid membranes. Their ammonium groups are protonated to form positive cations that carry halogen anion ions, that can kill the bacteria, into the cell membrane. Some bacteria can resist these agents by pumping the chemicals out of the cell. When these individual cationic groups are made insoluble by incorporating them into polycationic polymers, their concentrations remain high and constant, making them contact disinfectants—that are lethal to bacteria upon contact. Some antimicrobial agents can be incorporated into thermoplastic material that is injection molded at 200° to 250°C without losing its antibacterial effect.[4]

Tiller and colleagues have synthesized a series of polyvinyl pyridines that contain a long lipophilic alkyl chain (C_8-C_{16}) that can be covalently linked to many different types of surfaces following suitable surface preparation (eg, with ultraviolet or γ-rays, or microwave plasma).[5,6] Kuraray's antibacterial monomer (MDPB) is an example of such. The use of tertiary butylaminoethyl methacrylate is another approach to creating antimicrobial polyamide plastics.[7] Another example is the use of the amine reagent 1,4-diazabicyclo [2.2.2] octane attached to a lipophilic alkyl chain.[8] This approach is being used in the development of antibacterial textiles. Others have used phosphonium salts incorporated into polymers for an antimicrobial effect.[9]

In dentistry, covalent coupling of these antimicrobial polyamides to denture bases and ceramics, for example, requires that the surfaces be "activated" using high energies or strong reagents, which can be performed in laboratories but not in the mouth. These antimicrobial surfaces might lose their activity with abrasion, but it is possible they might be successful in denture bases. These products will soon be available in plastic water lines and water reservoirs of dental units, for example, which may eliminate biofilm contamination therein.[10]

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Expect to see these materials incorporated into combs, hairbrushes, toothbrushes, telephones, toys, counter tops, sinks, toilet seats, wallpaper, flooring, and clothing in the near future. Their broad antibacterial spectrum and insolubility in water may find many future dental applications.

REFERENCES

1. Imazato S, Torii M, Tsuchitani Y, et al. Incorporation of bacterial inhibitor into resin composite. J Dent Res 1994; 73:1437–1443.
2. Imazato S, Russell RRB, McCabe JF. Antibacterial activity of MDPB polymer incorporated into dental resin. J Dent 1995; 23:177–181.
3. Imazato S, Kinomoto Y, Tarumi H, et al. Antibacterial activity and bonding characteristics of an adhesive resin containing antibacterial monomer MDPB. Dent Mater 2003; 19:313–319.
4. Ito T, Matsumoto Y, Hiraki J, inventors; Antimicrobial resin composites and antimicrobial resin molded article comprising same. US Patent 6,294,183. 2001 Sept 25.
5. Tiller JC, Liao C-J, Lewis K, Klibanov AM. Designing surfaces that kill bacteria on contact. Proc Natl Acad Sci U S A 2001; 98:5981–5985.
6. Tiller JC, Lee SB, Lewis K, Klibanov AM. Polymer surfaces derivatized with poly(vinyl-*N*-hexylpyridinium) kill airborne and waterborne bacteria. Biotechnol Bioeng 2002; 79:465–471.
7. Ottersbach P, Hill F, Frank F, et al. inventors; Process for the preparation of antimicrobial plastics. US Patent 6,096,800. 2000 Aug 1.
8. Abel T, Cohen JL, Engel R, et al. Preparation and investigation of antibacterial carbohydrate-based surfaces. Carbohydrate Res 2002; 337:2495–2499.
9. Kanazawa A, Ikeda T, Endo T. Polymeric phosphonium salts as a novel class of cationic biocides. III. Immobilization of phosphonium salts by surface photografting and antibacterial activity of the surface-treated polymer films. Part A: Poly Chem. J Polym Sci 1993; 31:1467–1472
10. Lewis K. The middle of biofilm resistance. Antimicrob Agents Chemother 2001; 45:999–1007.

SUGGESTED READING

Lin J, Qiu S, Lewis K. Bacterial properties of flat surfaces and nanoparticles derivatized with alkylated polyethylenimines. Biotechnol Prog 2002; 18:1082–1086.

Tew GN, Liu D, Cheu B, et al. De novo design of biomimetic antimicrobial polymers. Proc Natl Acad Sci U S A 2002; 99:5110–5114.