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Allylimidazolium salt based antibacterial polymer coatings produced by thiol–ene photocuring

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ABSTRACT

Photocurable formulations containing trifunctional thiol, trifunctional ene, and antibacterial allylimidazolium salts have been employed for transparent antibacterial coatings. The antibacterial component 1-allyl-3-dodecylimidazolium salt (ADIm) is prepared and chemically attached to polymer networks using a one-step thiol–ene photocuring reaction. Ultra-small (USANS) and small angle neutron scattering (SANS) measurements show that the photocured polymers are loosely networked three-dimensional structures with a mass fractal of approximately 2.7 ± 0.2. The minimum inhibitory concentration (MIC) for the ADIm was determined to be 500 μg/ml and 15.63 μg/ml for *Escherichia coli* (Gram negative) and *Staphylococcus aureus* (Gram positive) bacteria, respectively. Coating formulations containing 10 mol% of the antibacterial ADIm photocured on glass substrates showed strong antibacterial activity against environmental bacteria such as *E. coli* and/or *S. aureus*.

1. Introduction

The public has increasingly become concerned about hygiene in everyday life. People share many objects with others such as door knobs, handles on public transportation vehicles, and touch screens, as well as personal objects such as cell phones, all of which can be contaminated by bacteria that cause communicable diseases [1]. It has been estimated that approximately 3–5% of patients leave the hospital with a nosocomial infection [2]. Bacteria-laden surfaces of intravenous poles and furniture in healthcare facilities can be sources for the pathogenic bacteria to spread to the public. Manufacturing objects with antibacterial materials could be a good alternative to reduce the probability of such infections. For example, metallic materials such as silver and copper have antimicrobial activity [3,4], which either inhibit bacterial growth of or kill bacteria attached to surfaces. However, the replacement of touchable objects currently in use with antibacterial materials is not cost effective. Conventional antibacterial agents also have limitations when applied to solid surfaces. For release-type antibacterial materials, the physically-mixed antibacterial ingredient is in a matrix, (e.g., dispersing antimicrobial in paint) and gradually leaks out over time. Antibacterial function is reduced by leaching and exhaustion of the low molecular weight antibacterial chemicals. Therefore, it is desirable to design new antibacterial materials and methods that do not leach and can be applied specifically to target surfaces while maintaining their original structural properties. To prevent antimicrobial agents from leaching, chemical binding of antibacterial monomers to polymer chains has been performed [5–16]. An effect of chain length on antibacterial activity was observed in homopolymers of quaternary ammonium salts (QASs) with different alkyl lengths [11], hydrophobic polycationic coatings [13], ionic liquids [14], and functionalized polyether ether ketone surfaces [15]. Most of these antibacterial materials require complicated design and application procedures. A simple method to fix the antibacterial ingredients to a cotton fabric using ultraviolet photocuring has been shown to kill waterborne pathogenic bacteria [17]. An overview of antibacterial mechanisms and new trends in antibacterial polymers has been reviewed [6–10,16,18]. Studies have focused on various antibacterial polymers [6,9,10], possible applications of Zwitterionic materials to kill bacteria [7], antibacterial material surfaces with polyelectrolyte multilayers

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