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Mini Review

Boric Acid-Incorporated Polyurethane Foams' Synthesis, Characterisation, and Study, as well as the Antibacterial Effects of Such Foams' Mattresses Characterization and Efficacy of Microorganisms

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Abstract

Polyurethane foam matrixes were filled with the antibacterial substances 2.4.4.′′-tricloro-2′′ hydroxydiphenyl ether (triclosan), 5-chloro-2-methyl-4-isothiazolin-3-one (isothiazolone), and bis(2-pyridylthio)zinc 1,1′-dioxide (zinc pyrithione). Each biocide component was utilised in concentrations of 0.20 weight percent, 0.50 weight percent, and 1.00 weight percent, and the ability to reduce infection for several species of bacteria was assessed (Barns et al., 2007). The colony formation units (CFU) as a function of time were examined during the microbiological testing with polyurethane foams utilising the pour plate technique and agar diffusion tests. Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Salmonella choleraesuis, and Staphylococcus aureus were employed in preliminary experiments. According to tests conducted in vitro, zinc pyrithione-containing polyurethane foam performed the best. In order to determine whether the usage of zinc pyrithione in polyurethane is harmful to human users, genotoxicity studies were carried out. In order to confirm the antibacterial qualities of polyurethane foam mattresses, microbiological tests were also run on the surfaces of those mattresses. The zinc pyrithione's efficiency as an antibacterial was proved by the large drop in the number of microorganisms found in the foam, and the results of the genotoxicity tests showed that there were no side effects for the users (Suriya et al., 2016).

In this work, brand-new polyurethane (BPU) foam with boric acid was created, and its various physical and biological characteristics were examined. Analytical (Fourier transform infrared spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, inductively coupled plasma optical emission spectrometry), morphological (scanning electron microscopy (SEM), micro-computed tomography), thermal characteristics (thermo gravimetric analysis, differential stoichiometry), and mechanical and physical properties (apparent density, contact angle), among others, were used to (Kumar et al., 2017). The PU foam's thermal and mechanical properties were improved by the inclusion of BA particles because BA's hydrogen bonds with PU reinforced the polymeric structure. Mechanical evaluations and contact angle measurements showed that, compared to PU foam, BPU foam had better mechanical characteristics (94.0 kPa) and greater hydrophobicity values (108.52). (52.9 kPa and 37.35, respectively). Micro-CT images supported SEM photos in which PU foam has an open cell structure and BPU foam has a closed cell structure, according to microscopy analysis. The findings of the antibacterial activity tests show that adding BA to the PU structure considerably enhanced the PU foam's antibacterial capabilities against both Gram-positive and Gram-negative bacteria. According to this study, adding BA to the PU foam's structure boosted its antibacterial qualities while also enhancing its physical, mechanical, and thermal characteristics. As a result, BA inclusion should be considered a viable option for enhancing the characteristics of PU foams (Ventura et al., 2007).

Keywords: Polyurethane, Boric acid, Mechanical properties, Antibacterial activity

INTRODUCTION

One of the major causes of morbidity and mortality for hospitalised patients is hospital infections. These infections cost hospitals the most in terms of money and are seen as a severe public health issue. Hospital infections account for 6.5% to 15.0% of all infections in Brazil on average, compared to 10.0% in Europe and the USA. Hospital infections might appear before the patient is released or during their stay. Hospital mattresses are likely the source of many infections in hospitals. Hospital infections are successfully reduced by preventative measures, but issues still persist, particularly in home health care. Many hospital patients spend a lot of time lying on a foam mattress. The danger of contracting an infection in a hospital is increased by either a lack of proper mattress hygiene or the application of biocide agents. Regular bacteria including S. aureus, E. coli, P. aeruginosa, Enterobacter spp., K. pneumoniae, and C. difficile, as well as fungi, primarily C. albicans, can cause these infections (Lee et al., 2008).

Isocyanates and polyols react to produce carbamate linkages via the backbone of polyurethane (PU), a type of polymer. Because the two different types of monomers are often arranged one after the other, it is referred to as an alternating copolymer. In order to create the perfect circumstances for biological applications, natural and synthetic polymers have recently been produced as biomaterials. Due to its perfect characteristics, including biocompatibility, minimal cytotoxicity, appropriate flexibility, and elasticity as compared to other polymeric materials, PU has grown in popularity (Lugtenberg et al., 2009).

With customizable absorbency, thickness, and pore size, PU is employed in biomaterials in the form of grafts, catheters, films, foams, sponges, sheets, and hydrogels. By incorporating various types of components into the polymer architectures, characteristic features of PU materials can be improved. In a study, curcumin was added to the PU hydrogel to increase its mechanical strength for use in tissue engineering and vascular transplant procedures. In a different study, adding Fe3O4 particles considerably enhanced the thermo-mechanical characteristics, antibacterial activity, and biocompatibility of hyper branched polyurethane compared to pure hyper branched polyurethane. The ability of hydrophilic polyurethane foam to effectively absorb exudates and maintain a steady moist environment has recently drawn particular attention. The impact of kaolin on the foam's ability to hemostasize when it is added to the PU framework. According to their findings, adding kaolin to the foam considerably improved its hemostatic properties (Brenelli et al., 2019).

Biocides with improper biocide additive parameters can encourage absences or weak antibacterial effects. Before using biocide additives for the creation of antimicrobial polymeric materials, it's vital to keep the following requirements in mind: (1) the biocide compound's chemical and physical compatibility with the polymeric matrix, (2) the weight percentage of the biocide compounds in the polymeric matrix, (3) the biocide additive's response to various temperature conditions, (4) the state of the processing equipment, and (5) the biocide additive's ability to kill particular bacterial types.

Polyurethane foam was treated with antimicrobial additives at three distinct weight percentages—0.20 weight percent, 0.50 weight percent, and 1.00 weight percent—for each bactericidal chemical. Triclosan, a bactericidal substance, was purchased from CIBA Chemical Specialty S.A., while Sigma-Aldrich provided the isothiazolone and zinc pyrithione (Steinheim, Germany). The bactericidal component caused the polyurethane to expand, creating the foam samples (Aiatwani 2016).

The polyurethane mixes, various antibacterial additives, and expansion agents were placed inside a commercial mould that had the following measurements: 2100 mm 1500 mm 1000 mm. Different weight percentages for each class of bactericidal agent were utilised, and the expansion reactions were pressure- and temperature-controlled (An et al., 2020).

CONCLUSION

Zinc pyrithione and isothiazolone bactericidal compounds showed the best results against the tested microorganisms of the antibacterial principles that were investigated. Less CFUs were found in mattresses with antimicrobial additions compared to mattresses without antimicrobial additives.

Only samples containing zinc pyrithione, the best addition among those considered, were subjected to the genotoxicity test. According to the statistical analysis test ANOVA, the biocide didn't cause any statistically significant alterations in the DNA of blood cells.

Zinc pyrithione at a concentration of 0.50 weight percent is appropriate for the production of polyurethane antimicrobial mattresses. Mattresses made of polyurethane foam can be utilised in hospitals effectively when paired with antibacterial chemicals (Barbosa et al., 2020).

Successful PU and BPU foam synthesis was followed by a comparison analysis of the foams' thermal, mechanical, analytical, and antibacterial characteristics. In comparison to PU foam, BA inclusion enhanced the density of BPU foam by 31%. Additionally, adding BA improved the compressive strength characteristics of the BPU foam in both the parallel and vertical directions to the swelling orientations (1.43 to 3.15 kPa in each direction for PU and BPU, respectively). The elastic modulus of BPU foam was found to be higher than that of PU foam (77.1 and 53.8 kPa in the parallel direction/94.0 and 52.9 kPa vertical directions, respectively) in a similar manner. The Tg value also increased, going from -42 to -46C, in accordance with the BA inclusion (Blunt et al; 2016).

While PU foam exhibits hydrophilicity, BPU foam exhibits hydrophobicity. SEM and micro-CT micrographs showed that adding BA to the PU structure increased pore diameters but changed the position of the pores from open to close in the cell structure. With the addition of BA, PU foam acquired antibacterial characteristics and demonstrated at least an 81.3% reduction in germs tested. This study shows that the thermal, mechanical, and antibacterial properties of the novel BPU foam make it a more acceptable biomaterial for biomedical applications. It must be concluded that BAincorporated PU foam can be categorised as a viable antibacterial biomaterial and an intriguing alternative to its non-modified commercial forms, despite the fact that in vitro and in vivo experiments of the BPU foam have reinforced and clarified its biomedical uses.

REFERENCES

1. Barns SM, Cain EC, Sommerville L, Kuske CR (2007). Acidobacteria phylum sequences in uranium-contaminated subsurface sediments greatly expand the known diversity within the phylum. Appl Environ Microbiol. 73: 3113-3116.
2. Suriya J, Shekar MC, Nathani NM, Suganya T, Bharathiraja S, et al (2016). Assessment of bacterial community composition in response to uranium levels in sediment samples of sacred Cauvery River. Appl Microbiol Biotechnol. 101: 831-841.
3. Kumar V, Chandra R (2017). Bacteria-assisted phytoremediation of industrial waste pollutants and ecorestoration. In Phytoremediation of Environmental Pollutants. CRC Press. pp: 159-200.
4. Ventura M, Canchaya C, Tauch A, Chandra G, Fitzgerald GF, et al (2007). Genomics of Actinobacteria: Tracing the Evolutionary History of an Ancient Phylum. Microbiol Mol Biol Rev. 71: 495-548.
5. Lee SH, Ka JO, Cho JC (2008). Members of the phylum Acidobacteria are dominant and metabolically active in rhizosphere soil. FEMS Microbiol Lett. 285: 263-269.
6. Lugtenberg B, Kamilova F (2009). Plant-growth-promoting rhizobacteria. Annu Rev Microbiol. 63: 541-556
7. Brenelli LB, Persinoti GF, Cairo JPLF, Liberato MV, Gonçalves TA, et al (2019). Novel redox-active enzymes for ligninolytic applications revealed from multiomics analyses of Peniophora sp. CBMAI 1063, a laccase hyper-producer strain. Scientific Rep. 9:17564.
8. Aiatwani RRH (2016). In vitro, optimization of antibacterial activity of secondary metabolites produced by endophytic fungus Stemphylium radicinum in Iraq. Eur Acad Res. 3:11957–11967.
9. An C, Ma S, Shi X, Xue W, Liu C, et al (2020). Isolation, diversity, and antimicrobial activity of fungal endophytes from Rohdea chinensis (Baker) N.Tanaka (synonym Tupistra chinensis Baker) of Qinling Mountains, China. Peer J. 8: 1-20.
10. Barbosa F, Pinto E, Kijjoa A, Pinto M, Sousa E (2020). Targeting antimicrobial drug resistance with marine natural products. Int J Antimicrob Agents. 56: 1-29.
11. Blunt JW, Copp BR, Keyzers RA, Munro MHG, Prinsep MR (2016). Marine natural products. Nat Prod Rep. 33: 382-431.