MECHANICAL PROPERTIES OF POLYMER BEADS AFTER IMMERSION IN SOLUTIONS OF DIFFERENT pH

NATALIA STACHOWIAK*, JOLANTA KOWALONEK, JUSTYNA KOZLOWSKA

FACULTY OF CHEMISTRY,
NICOLAUS COPERNICUS UNIVERSITY IN TORUN, POLAND
*E-MAIL: NAT.STA@DOKTORANT.UMK.PL

[ENGINEERING OF BIOMATERIALS 163 (2021) 110]

Introduction

Natural polymers, such as sodium alginate and gellan gum, are widely used in skin care products, medicine, and materials science. These polysaccharides are biodegradable, non-toxic, and biocompatible [1]. Gellan gum and sodium alginate are used for the production of transporting active substance particles and as a platform for drug delivery systems [2].

Sodium alginate is an anionic linear polysaccharide extracted mainly from brown algae [3]. It is composed of α-L-guluronic acid and β-D-mannuronic acid residues linked by a glycosidic bond [4]. Sodium alginate can transform into a hydrogel by reacting with divalent cations such as Ca^{2+} and Ba^{2+} [5].

Gellan gum is another anionic polysaccharide, similar in utility profile to alginate. Gellan gum forms transparent heat-resistant gels [6]. It consists of repeating units of d-glucose, l-rhamnose, and d-glucuronic acid [7].

Decyl glucoside (DG), as a long-chain alkyl glucoside (FIG. 1), has been applied in cosmetic formulations as a mild non-ionic surfactant with excellent washing properties, biodegradability and low toxicity [8].

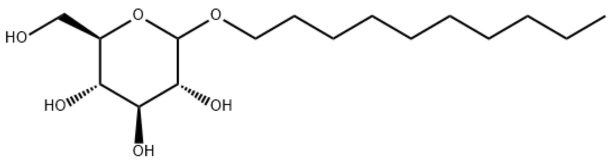

FIG. 1. Structure of decyl glucoside.

The aim of this study was to produce beads based on biodegradable polymers (sodium alginate and gellan gum) containing surfactant (decyl-glucoside) to provide the washing properties of the beads. The mechanical properties of the beads after immersion in solutions with acidic, neutral, and alkaline pH were examined.

Materials and Methods

Sodium alginate (ALG) was supplied by BÜCHI Labortechnik AG (Flawil, Switzerland). Gellan gum (GG) was purchased from Sigma-Aldrich (Poznan, Poland). Calcium chloride was supplied by Stanlab (Lublin, Poland). Decyl glucoside (DG) was acquired from Greenaction (Kielce, Poland).

Beads based on sodium alginate (ALG) and gellan gum (GG) containing non-ionic surfactant (Decyl Glucoside) were prepared by extrusion method. Polymer solutions with surfactant were put into a syringe with a needle (diameter 1.2 mm) and dropped to crosslinking solution (0.5M $CaCl_2$).

The obtained beads were immersed in solutions:

- Sodium acetate buffer (pH = 4) – acidic
- Phosphate saline buffer (pH = 7) – neutral
- 1% Na_2HCO_3 (pH = 9) – alkaline

The mechanical properties of the polymer beads were conducted at room temperature using a mechanical testing machine equipped with compression jigs (EZ-Test SX Texture Analyzer, Shimadzu, Kyoto, Japan). The wet samples and after 2 h of immersion in different conditions were examined. The tests were carried out at a compression speed of 1 mm/min up to 50% of strain. Young's modulus was determined. The results were recorded by Trapezium X software.

Results and Discussion

The obtained results showed that gellan gum beads exhibited higher values of Young's modulus compared to sodium alginate beads. The GG samples were stiffer, while the ALG samples were more flexible.

The values of elastic moduli were also dependent on the pH of immersing solution. In the case of both types of samples, the values of Young's modulus increase with the higher pH of solutions. The beads were stiffer in alkaline solution than at acidic pH.

Conclusions

The beads' stability in different pH is essential for the application to the skin and used in skin care products and drugs. Moreover, materials with cleaning agents should indicate appropriate pH to effectively remove dirt and other contaminants.

The next stage of the research will be the introduction of beads based on natural polymers with a surfactant into the matrices which can be used as skin-safe and biodegradable cleaning products.

Acknowledgments

Financial support from the National Science Centre (NCN, Krakow, Poland) Grant No 2018/31/N/ST8/02007 is gratefully acknowledged.

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