

ABSTRACT

Wet wipes are moist, disposable wipes that are soaked in various substances depending on their intended use. They can be used in many situations, from personal hygiene and baby care to cleaning different surfaces. They have a wide range of applications, both in everyday hygiene and in maintaining cleanliness at home or while traveling. However, wet wipes pose a significant threat to the environment, mainly due to their widespread use and difficulties with biodegradation. The biodegradability of these materials is an important factor, especially in the context of environmental protection. Most wet wipes are made from synthetic materials such as polyester or polypropylene. These fibres do not break down quickly in the environment, and their biodegradation can take hundreds of years. As they decompose, synthetic wipes can break down into microplastics, which enter the soil and water, posing a threat to aquatic organisms and entire ecosystems. Furthermore, wipes flushed down the toilet can cause the formation of so-called "fatbergs" – large blockages made up of fat, oil, and waste that clog sewage systems. Clearing these blockages incurs huge costs in many countries. Moreover, there is a recycling problem with wet wipes due to their mixed composition, leading to the accumulation of these wastes in landfills. Therefore, there is a need to design new, degradable materials that can be an alternative to wet wipes.

The main goal of this study was to design, obtain, and characterize innovative surfactant-containing materials as a replacement for wet wipes. This process involved the development and optimization of the composition of biodegradable matrices as well as micro- and macroparticles, along with the selection of substances with cleaning properties (surfactant).

In the first experimental paper, films based on poly(vinyl alcohol) and chitosan with the addition of a plasticizer (glycerin or sorbitol) and a surfactant (cocamidopropyl betaine) were obtained and characterized. The contact angle of the samples was measured, images of the films were taken using atomic force microscopy (AFM), and the roughness parameters of the samples were calculated. Chemical interactions between the film components were investigated using attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR). Mechanical tests of the prepared polymer films were carried out using a tensile testing machine. Their Young's modulus, stress at break, and elongation at break were determined. The moisture content of the prepared materials was also evaluated.

In the next experimental publication, three-dimensional polymer matrices consisting of gelatin, hydroxyethyl cellulose, and polyvinylpyrrolidone with the addition of glycerin and microparticles containing a surfactant were obtained. Microparticles made of sodium alginate and sodium alginate with pectin, containing a non-ionic surfactant (polyglycoside of coconut oil acids), were prepared. The obtained microparticles were added to the polymer matrices, which were produced using the lyophilization method. The appearance of the microparticles was examined using optical microscopy. Images of the swollen, dry, and rehydrated microparticles were taken. The size and size distribution of the obtained microparticles were measured using a particle size analyzer based on laser diffraction. In the next stage of the study, the polymer matrices with added microparticles were characterized. Images of the materials were taken using a scanning electron microscope (SEM). The porosity, density, and solubility of the prepared materials were evaluated. Swelling tests of the polymer matrices were conducted, and their thermal stability was determined. The mechanical properties of the obtained matrices were also investigated using a mechanical testing machine equipped with compression tools.

In the final experimental paper, macroparticles made of sodium alginate, gellan gum, and a mixture of these biopolymers containing a surfactant (decyl glucoside) were obtained using the ionotropic gelation method. The stability of the prepared macroparticles was determined after immersion in solutions of varying pH for 2, 4, and 24 hours. Observations were conducted in the pH range of 4–10. The appearance of the macroparticles was observed using optical microscopy, and their diameters were measured. Next, the mechanical properties of the prepared macroparticles immersed in solutions of different pH levels were analyzed. In the final stage of the research, the biodegradation of the prepared macroparticles in soil and seawater was assessed using the respirometric method.

The results of this doctoral thesis may contribute to the development of fully degradable materials that could successfully replace commercially available non-degradable wet wipes. The urgent need to reduce plastic consumption stems from growing concerns about plastic pollution and its accumulation in aquatic environments and landfills. In response to these global challenges, the development of eco-friendly solutions, such as biodegradable wet wipes, represents a promising approach. The inclusion of such environmentally friendly alternatives could help mitigate the harmful impact of plastic waste on the environment.

Keywords: biodegradable polymers, environmental pollution, macroparticles, microparticles, surfactants, wet wipes