Wrocław, dnia 2023-06-13

Marcin Janusz Bartman
Wybrzeże Wyspiańskiego 27, 50-370 Wrocław
698 140 445; marcin.bartman@pwr.edu.pl

ABSTRACT

This doctoral thesis focuses on the development, analysis, and evaluation of nanostructured water-in-oil nanoemulsion fluids stabilized with specific surfactants derived from renewable raw materials. These fluids are designed as environmentally-friendly alternatives to traditional removers for removing different types of graffiti coatings from delicate surfaces that cannot withstand mechanical cleaning. High-pressure emulsification (HPH) was used to fabricate detergents with nanotechnological properties. The nanodetergents were successfully obtained through meticulous experimental planning and precise process parameters. These nanodetergents possess specific utility features and functionality, including the desired size, low polydispersity, high kinetic stability, excellent wetting properties, versatility in removing various types of graffiti coatings, and resistance to cleaned surfaces. The resulting formulations without nanoemulsion were stable detergent systems designed for effectively cleaning surfaces that are sensitive to mechanical cleaning, such as those covered in different types of graffiti coatings.

Experimental planning was conducted at each stage of the research work to determine the optimal parameters for obtaining biosolvents and w/o nanoemulsions. Suitable surfactants were also selected to stabilize the colloidal system and meet the physicochemical and functional criteria necessary for modern, eco-friendly detergents. Oil-PEG-8 ester biosolvents were synthesized using different vegetable oils such as rapeseed, sunflower, and cooking oil. In addition, environmentally friendly solvents, including ethyl lactate, D-limonene, and 3-methoxy-3-methyl-1-butanol, were utilized as constituents of the oil phase. Colloidal systems of water-in-oil nanoemulsions were stabilized using ecological alkylpolyglucoside or amino acid surfactants derived from natural raw materials. The nanoemulsions produced with this method are contemporary formulations that integrate many functionalities, making them suitable for the "brush on, wipe off" cleaning technique.

The characterization of the w/o nanoemulsions involved measuring the droplet sizes, polydispersity indices, and kinetic stability. The nanoemulsions were analyzed utilizing techniques such as optical microscopy, dynamic light scattering (DLS), and thermokinetic stability by measuring the Turbiscan Stability Index (TSI). The research done enabled the identification of w/o nanoemulsions with the most advantageous physicochemical characteristics. The nanoemulsions obtained varied in size from 100 to 500 nm, depending on the type of surfactant used for stabilization. These nanoemulsions had a polydispersity index (PdI) of less than 0.1 and a TSI (parameter change) of less than 5 units within a 90-day period.

The surface qualities of graffiti coatings and materials such as natural stone, glass, marble, and aluminum were analyzed using optical microscopy, optical profilometry, and

infrared spectroscopy with attenuated total reflection. Fourier transform. Attenuated Total Reflection (ATR) ATR-FTIR stands for Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy. The evaluation of the wetting characteristics (wettability) was conducted by measuring the angle at which water recedes (θ_a) and the angle at which it recedes completely (θ_r). The surface free energy (γ_S) was computed using a model based on contact angle hysteresis (CAH) established by Chibowski.

Using the collected data, a novel cleaning system was created, relying on the "brush on, wipe off" principle. Its efficacy was then evaluated in controlled laboratory settings as well as on various real surfaces, including glass, metal, aluminum, natural stone, acrylic glass, and marble. The technology's efficiency and effectiveness were evaluated through the assessment of wetting properties, specifically by measuring the advancing contact angle (θ_a) of the detergent nanoemulsion and determining the work of spreading (W_s). Additionally, the degradation kinetics of the graffiti coating were examined, and its effectiveness was assessed. Elimination of graffiti residue with the application of optical microscopy, optical profilometry, and attenuated total reflection. Fourier transform infrared spectroscopy (FT-IR) is a technique used to analyze the infrared spectrum of a sample by converting it into a frequency domain representation.

The research demonstrates that the nanoemulsions created without the use of renewable raw materials-based surfactants, which are nanotechnological detergents, can serve as a novel substitute for conventional solvent-based graffiti removers. The findings of the presented research demonstrate that w/o nanoemulsions has the capability to efficiently eliminate graffiti from public areas across different surfaces, hence exhibiting significant prospects for commercial utilization.