Recycling and revalorization of high concentration DMSO specialty chemicals used for photoresist stripping in semiconductor manufacturing by low pressure distillation

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Résumé

In semiconductor manufacturing, specialty chemicals based on dimethyl sulfoxide (DMSO) are essential for the removal of photoresists (photosensitive polymers) in a process known as stripping (part of photolithography process). DMSO is an aprotic and polar organic solvent, miscible in water, with relative low toxicity (not classified by ECHA, no GHS label (1)), excellent solubilization properties (2), and used for N-methyl-2-pyrrolidone (NMP) replacement (3). At low DMSO concentrations in aqueous solutions, the solvent is usually submitted to water treatment processes after usage (4). However, in semiconductor manufacturing the high concentration solvent is often disposed by chemical incineration after usage, creating toxic and greenhouse gases. The European electronics environment is also suffering from sourcing issues, due to the closing of DMSO production sites. This results on an increase of imported raw materials, transport and stockage. All these factors contribute to high emissions of pollutants in the DMSO disposal process and greatly increases the carbon footprint of the solvent lifecycle. The lack of both experimental and theoretical data in scientific literature for treatment of these high concentration DMSO mixtures drives this research opportunity within the R&D team of Technic France in collaboration with ESCOM university.

In this study, we used a combined experimental and computational approach to ensure the feasibility of the desired separation of DMSO from potential impurities as well as other products in the formulation guided by simulated values of process parameters. Using this methodology, binary DMSO/co-solvent mixtures were studied, and a high degree of purity and yield were obtained for our target solvent, characterized by 80 MHz proton nuclear magnetic resonance (1H NMR). This was achieved by using a lowpressure batch distillation column to avoid solvent degradation (2) and decrease separation time. Ternary mixtures with commonly used additives, such as amines and other co-solvents, will also be investigated. In addition, a lifecycle assessment (LCA) of the current process will be compared to the recycling scenario developed on this study in a quantitative fashion to demonstrate the possible environmental impact of the project.

*Intervenant

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