Solvent-assisted high pressure switchable water (SA-HPSW): an alternative method for separating ethanol from water

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Bioethanol, in the past 30 years, has become one of the most promising replacements for gasoline; however, the greenness of this fuel alternative is still a point of concern. One of the challenges faced by bioethanol production is associated with the purification and isolation of the ethanol produced. Large amounts of water are used in the reaction, and the ethanol concentration is low. As a result, large amounts of energy are necessary to recover the ethanol during distillation. This significant energy consumption arises from the removal of water, a molecule with very poor thermal properties. If we are to attain a truly sustainable production of bioethanol, we need to find separation techniques capable of replacing or diminishing the impact of distillation.

Looking to address this issue, we developed a new method for separating hydrophilic organics from water: high pressure switchable water (HPSW). HPSW takes advantage of two strategies previously described in the literature: CO_2 expansion of liquids (CXL) and CO_2-switchable water (SW). CO_2 dissolves better in organics than in water, which promotes the expansion of the organic phase, among other changes. This expansion triggers the separation of organics from water. SW uses amines to increase the ionic strength of aqueous solutions when CO_2 is present. They then disrupt the interaction between the species in the system, causing the expulsion of organics from water. Individually, these techniques cannot promote the effective removal of hydrophilic organics from water. By combining them, we demonstrated a synergistic effect and the efficiency of several amines in promoting phase separation of acetone from water at lower pressures than CXL alone. The same was not observed for aqueous ethanol solutions. Due to ethanol's elevated hydrophilicity, phase separation was not observed even when high amine concentrations were used in combination with 100 bar of CO_2.

Due to the importance of ethanol for the migration to a more sustainable fuel grid, we modified our original HPSW method to create a new method: solvent assisted high pressure switchable water (SA-HPSW). This modification allowed us to separate ethanol from water. In this process, instead of relying only on the changes in the interactions between ethanol and water, a less hydrophilic secondary extracting solvent was added to the system to improve phase separation. Our goal is to optimize the HPSW and SA-HPSW separations, reducing their energy consumption compared to conventional processes. By doing so, we can hopefully make biomass-derived products more competitive with petroleum-based chemicals in terms of economic cost and environmental impact.