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Development of CO_2-assisted dispersibility of organic-inorganic hybrid nanoparticles with expanded liquid solvent mixtures

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Key Word (3 words)

Solubility parameter, Solvent selection, Nanoparticles

Abstract

Applications of organic-inorganic hybrid nanoparticles (NP) require a suitable solvent to have high dispersibility in terms of target objectives. According to the literature [1], pure nonpolar solvents (e.g. cyclohexane and hexane) can be a suitable solvent to provide high dispersibility for decanoic acid-modified NP (homogeneous solution), while pure polar solvents (e.g. ethanol and water) caused turbid solution due to agglomeration in NP. The limitation of NP processing comes from a small number of suitable pure solvents due to attractive forces between the particles and the complicated interactions between surface chains of NP and solvent molecules. In this sense, the first objective of this work is to propose a method for selecting suitable solvents by extending the candidate into binary solvent systems. The second objective is to develop a CO_2-expanded liquid process for controlling NP dispersibility.

In this work, the literature data of NP and a solvent [1] were analyzed and were found that the dispersion solubility parameter (δ_d) and the van der Waals volume (V_{vdw}) are key parameters for defining suitable solvents, where favorable ranges were δ_d ($\approx 15 - 17$ $MPa^{0.5}$) and V_{vdw} (< 89 $cm^3 \cdot mol^{-1}$). To validate the favorable ranges, CO_2 was chosen to study because its δ_d (≈ 15.6 $MPa^{0.5}$) and V_{vdw} (19.7 $cm^3 \cdot mol^{-1}$) values are within the favorable ranges. In order to demonstrate the role of CO_2 in dispersion, the experiments were conducted by the addition of CO_2 into solutions. The studied conditions were 1wt% hybrid CeO_2 nanoparticles in solutions (decane solvent), the temperature of 40 °C and pressure from 2 to 6 MPa using a high-pressure observation. It was found that the addition of CO_2 could cause a change of turbid solution to clear solution, namely increasing the dispersibility. These results imply that the δ_d and V_{vdw} favorable ranges can be used to identify a suitable solvent and CO_2-expanded liquid solvent mixtures can be a suitable alternative solvent for NP processing.

Reference

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MTMS ’21