supercritical-co2-solvent

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608-238-6001 [TEL]

greg@cruisingreview.com [Email]

Cruising Review

Supercritical Carbon Dioxide: A Solvent like no Other

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This article discusses the benefits of replacing the widespread use of volatile organic compounds (VOCs) with the use of Supercritical Carbon Dioxide (SC-CO2) along with the challenges presented and explores recent attempts to improve the process.

PDF Version of the webpage (first pages)

Supercritical Carbon Dioxide: A Solvent like no Other

1. This article discusses the benefits of replacing the widespread use of volatile organic compounds (VOCs) with the use of Supercritical Carbon Dioxide (SC-CO2) along with the challenges presented and explores recent attempts to improve the process.
2. SC-CO2 is an attractive replacement option for VOCs for multiple reasons: it is inexpensive, easily available, not restricted by the EPA, non-toxic, food process safe, and currently in use in multiple industries.
3. As the authors point out, quote – SC-CO2 suffers from a range of inconvenient physio-chemical properties ordinarily required for an effective solvent – unquote. Its nature as a non-polar, linear molecule gives it a poor ability to dissolve polar solutes.
4. There is a desire in the scientific community to increase the viscosity of CO2 which would allow for easier handling and process development. So far there has been some progress towards this goal with the use of surfactants and polymers.
5. The ability to influence solubility is another critical factor that requires additional development to fully realize the potential of carbon dioxide. Currently the primary means of solubility influence are pressure, temperature, and system polarity.
6. The polarity of a given molecule is determined by the electrical distribution of its molecular structure. If one area of the molecule is significantly more positive or negative than another, the molecule is said to be polar. If the charges are balanced across the molecule, the material is no- polar.
7. One type of surfactant that has shown promise is those that are fluorocarbon-based. Their high solubility in liquid and SC-CO2 is the reason for their prominence.
8. These fluorocarbon-based surfactants have been used to create microemulsions which are, quote – stable dispersions of two or more immiscible/partially miscible fluids which are stabilized through the addition of amphiphilic molecules, such as surfactants and polymers – unquote.
9. Although fluorocarbon-based surfactants offer significant advantages, their environmental impact and therefore expense is relatively high.
10. In search of a replacement for fluorocarbon-based surfactants, quote – hydrocarbon based, siloxane based, and carbonyl based / oxygenated surfactants – unquote are being investigated.
11. Investigations have shown that fluorinated surfactants tend to have greater tail volume when compared to similar hydrocarbons. Hydrocarbon surfactants with slightly larger tail volumes have shown to be more compatible with carbon dioxide.
12. Similar to the surfactant method of improving SC-CO2's affinity for polar solutes, polymers also offer a possible solution. As with the surfactants, fluorinated polymers were the first successfully investigated but also share the negative environmental impacts.
13. Siloxane polymers have, quote – the highest solubility of all known non-fluorinated polymers in carbon dioxide – unquote.
14. Viscosifiers are materials that can influence the viscosity of CO2 through increasing internal structure. These viscosifiers, many of which are still under development, offer another means of tuning SC-CO2 solvency.
15. Previous studies have indicated that use of polymeric CO2 viscosifiers have been able to generate CO2 viscosities, quote – 13 to 14 times higher than that of pure CO2 – unquote.

16. The addition of low molecular weight polymers has also shown potential to significantly influence CO2 viscosity.
17. Room temperature ionic liquids share many of the beneficial attributes as CO2 and are more compatible with polar materials. Naturally, scientists are working to combine the two in hopes of creating a microemulsion with much greater solvency than CO2 on its own.
18. Overall, this article summarizes much of the recent investigation that has taken place to improve the solvency of SC-CO2, primarily using soluble surfactants, polymers, and ionic liquids. While significant advancements have been made, much is still left to develop to maximize the potential for SC-CO2 to replace the use of organic solvents.

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