

General Solvent Substitutions

Cleaner solvent alternatives:

1) Natural products (non-petroleum based)

Examples: Ester solvents such as soy methyl esters are derived from fatty acids of soy bean oil.

2) Coproducts

Examples: Lactate esters, that can be used as a cleaning agent, are by-products of the corn-milling industry

Examples: By-products in the production of adipic acid that is used to make nylon, can be treated with methanol to make dibasic esters of leftover acids. DBEs has already replaced methylene chloride in the paint stripping industry.

3) Solventless reactions

Examples: Solid-state chemistry- essentially grinding chemicals together

Be careful to compare the benefit of not using a solvent in a reaction to any later steps, such as extractions, that might still use solvents

4) Ionic liquids:

These are molten salts that have low melting points, are non-volatile, and recoverable and can act as a solvent and/or catalyst. The solubility characteristics of ionic liquids can be changed by modification of the cation, such as changing the length of alkyl chains.

Note: Research is still being conducted on the properties and toxicity of this alternative.

5) Supercritical Fluids

6) Catalysts:

a) Zeolites- clays with micropores that can be used in chemical synthesis, such as in Friedel-Crafts reactions

b) Supported catalysts- such as using molecular sieves or titanium silicates, alumina, and other inorganic supports

- c) Polymer supported catalysts- here product can be easily separated from the catalyst. The catalyst can be easily recovered and used again because it is attached to an easily removable polymer through a long chain that avoids interfere with reactants in the catalytic site of the reaction.
- d) Biocatalysts- these are usually aqueous, operate under ambient pressure and temperature, and can be stereospecific
- e) Photocatalysis- energy efficient and can be done in aqueous solutions

7) Water as a solvent (aqueous reactions)

Examples:

Aqueous surfactants and macromolecular solutions have also exhibited good solubilization of organic compounds in micellular solutions in which the extraction solution can be regenerated after removal of organic compound.

8) Innovative technologies

- a) Microwave batch reactors- these can be used to run reactions under controlled temperature, pressure, and at accelerated rates (decreasing hours to minutes) since samples are superheated directly in a contained vessel rather than through a secondary medium, such as an oil bath.

Example: This has been widely used by major pharmaceutical companies.

- b) Ultrasound - the use of frequencies above human hearing creates mini-implosions of liquid bubbles that form in solution to create a unique environment for chemical reactions. Reactions that would otherwise occur at high temperatures and pressure can be run using ultrasound at room temperature and ambient pressure.

Example: This has been used in organometallic and heterogeneous organic reactions.

- 9) Immobilized solvents- can provide polymer supported reagents that can be recovered and used again

- 10) Microencapsulated Lewis acids can be used in lieu of more corrosive Lewis acids.

Other Safer technologies available:

- 1) Prepacked silica columns can be used to replace the packing and disposing of silica gel in FLASH chromatography using glass columns while still providing product in high purity.

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