



A Green Solution to Turn Waste into Gold

\$5 Million from 800 metric tons of trash.....A new recycling plant to recover valuable uranium from radioactive garbage will soon be operating at the Richland, WA facility of AREVA, an international nuclear energy leader.

Bjorksten | bit 7 has been working with AREVA and the University of Idaho on a novel process to recycle uranium from the ashes of low-level radioactive waste generated on-site. Ray Robey, Manager of Research & Development, helped finalize the design and operational features of the first commercial operation at AREVA. The plant is currently under construction and should be ready in 2009. After treating on-site inventory, the facility will be ready to accept shipments of similar ash from nuclear power plants as well as from nuclear medical facilities throughout the country.

The surprising key to this “green” process is carbon dioxide. When pressurized to its supercritical state, carbon dioxide is a chemically inert, non-toxic, inexpensive and easily recyclable solvent. The extraction process takes advantage of the unique properties of a supercritical fluid to dissolve compounds like a liquid. When the pressure is lowered, the supercritical fluid evaporates leaving behind the extracted materials.

Bjorksten | bit 7 has expertise in diverse technology areas and has used this knowledge to provide unique solutions and Intellectual Property opportunities for our clients. For additional information regarding the science of processing with Supercritical fluids, please contact Ray directly at rrobey@bjorksten.com .

To learn more about Bjorksten | bit 7 and how we apply science to the new product development process, please contact: info@bjorksten.com

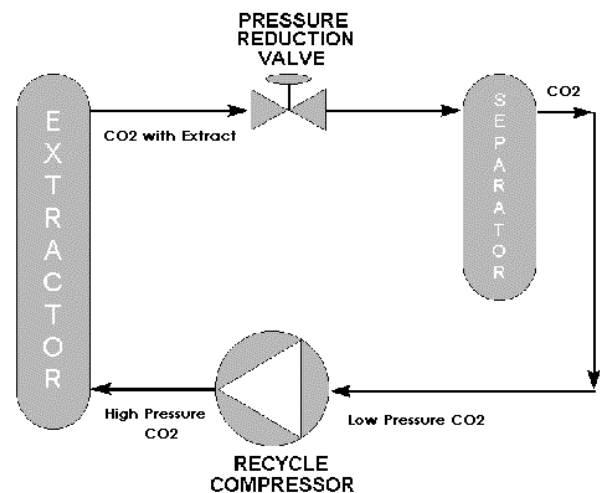
Applications of Supercritical Fluid Processing

Dense phase CO₂, with unique physical and thermodynamic properties, has been commercialized for more than three decades and is being used for a variety of applications (see below) that has proven to be superior to alternative methods.

Extraction - The most widely known application of supercritical carbon dioxide is an extraction solvent, particularly for foods and natural products. Decaffeinated coffees and teas, hops extracts for beer, fat-free cocoa products, and a variety of spice extracts produced via supercritical CO₂ extraction are all commercially available. The advantages of using supercritical CO₂ as an extraction solvent are generally recognized as being; 1) the ability to extract with a non-chlorinated, non-carcinogenic, non-flammable solvent that is generally perceived as benign, and 2) the ability to extract and to recover extracted products from a solvent at mild temperatures, eliminating degradation due to heat. A simple representative flowsheet of an extraction process is shown.

In this process, supercritical CO₂ at a high pressure is passed through an extraction vessel where it contacts a feedstock. The CO₂, acting as a solvent, dissolves a fraction from the feed. The extract is easily recovered from the CO₂ by reducing the pressure of the CO₂ until its density is so low that it no longer has good solvent properties. The extract separates from the CO₂ as a pure, solvent-free material. The CO₂ leaves the separation vessel at low pressure, is recompressed to conditions where its solvent power returns, and is directed back to the extractor. There is a transition in the application of this extraction technology from low-value commodity products (foods), to higher value materials such as spice extracts, specialty chemicals and pharmaceuticals.

Cleaning - A close corollary to extraction is cleaning with a dense phase CO₂ solvent. The ability of CO₂ to remove oils, greases and other organic contaminants from surfaces has been demonstrated on a variety of systems from the sophisticated (inertial guidance systems, nuclear weapons components, computer hard drives), to the mundane (contact lenses, o-rings, nuts & bolts, ball point pen tips). In all of these applications, it is the environmental benefit of replacing a halogenated solvent with CO₂ which has served as the driver. CO₂'s inability to efficiently dissolve high molecular weight species or inorganic contaminants has been remedied by the addition of modifiers, co-solvents

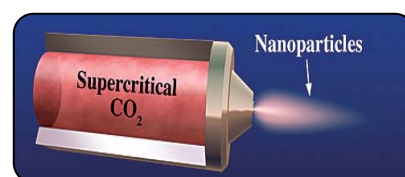


or surfactants to dense phase CO₂. These modified solvents have extended the application of this technology to such areas as cleaning up contaminated soils and even the “dry cleaning” of clothes.

Dyeing - Another related application under development is the dyeing of textiles using supercritical CO₂ as the working fluid, in place of water. Already demonstrated at the lab scale, this application provides the benefits of avoiding the cost of process water, the cost of water treatment, and the cost of drying dyed textiles. In addition, the enhanced transport properties of supercritical CO₂ have reduced the conventional dyeing cycle time by more than 50%.



Production of Micron Sized Particles - There is no easy way to produce micron size powders of thermally labile materials. Current processes involve mechanical grinding that often produces enough heat to convert these products into a paste. In addition, wide variation in particle size limits the usefulness of any recovered product. However, the properties of supercritical CO₂ can be used to produce particles in very narrow particle size ranges. Rapid expansion of supercritical solutions, (RESS), is used for non-polar materials which can be dissolved in supercritical carbon dioxide and sprayed, as in spray drying. As the CO₂ flashes off at low pressure, very pure sub-micron particles are left behind. This technique is used for pharmaceutical materials such as steroids, asthma medicine, and controlled release drugs.



For polar materials which typically exhibit little or no solubility in supercritical CO₂, supercritical antisolvent (SAS) process is a great choice. The SAS precipitation process is performed by spraying a solution of the desired material in organic solvent into a vessel containing supercritical carbon dioxide. The spray causes a rapid mixing of the solution and carbon dioxide antisolvent. Since carbon dioxide is a poor solvent for most polar substances, supersaturation of the solute quickly occurs, followed nucleation and precipitation of the solute typically as microparticles.

Reactions - The idea of carrying out chemical reactions in a dense phase CO₂ solvent is currently receiving considerable attention, not only from academicians, but from major multinational chemical and pharmaceutical firms. Potential benefits include the elimination of liquid organic and chlorinated solvents, improved reaction rates due to enhanced mass transfer properties, improved selectivity and yield due to the differing solubilities of reactants, products and by-products, and enhanced heat removal from exothermic reaction systems. A variety of reaction systems, (catalytic, bio-catalytic, organometallic, etc.) are currently under study.



Ray Robey, Director, Research, Development and Testing, is a chemical engineer with over 30 years of experience in process development & scale-up. He has directed many programs from table-top, through pilot plant and semi-works, to full scale start-up. Ray has developed applications for numerous industries, including foods, pharmaceuticals, textiles, pulp & paper, and semiconductor processing. He was responsible for the development of many of the key process parameters for utilizing liquid and supercritical carbon dioxide as solvents and has been instrumental in the commercialization of coffee decaffeination, hops extraction, nutraceutical production and precision cleaning processes. Ray holds six patents, is the recipient of the 2002 U.S. EPA Presidential Green Chemistry Award, and has authored twenty five papers & presentations.

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