Recovery of liquid hydrocarbons from oil shale using supercritical CO_2

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Over the past two decades, supercritical fluids (SCFs) have developed into unique and valuable materials, and now occupy an important role in process chemistry and industry. They combine the most desirable properties of a liquid with those of a gas; these include extremely low surface tension, high mass and thermal transfer characteristics, the ability to dissolve organic materials, and total miscibility with other gases. The unique physical and transport properties of SCFs are intermediate between those of a liquid and a gas, and they vary with density, which is a function of temperature and pressure above the critical point. Hence, SCFs provide the opportunity to engineer the reaction environment by manipulating temperature and pressure. CO_2 is the most frequently used SCF in other industrial processes because of its low cost and convenient critical conditions (critical temperature and pressure are 304.2 K (31°C, 88°F) and 72.8 atm, respectively). Supercritical (sc) CO_2 has displaced halogenated and aromatic solvents in several industrial processes as an environmentally benign substitute. SCFs, and in particular $scCO_2$, reduce drastically the viscosity of heavy hydrocarbons or condensed phases, making it particularly effective in extracting organic components from oil shale. Miscibility of the hydrocarbon phase is significantly increased because the surface tension between the reaction medium and the hydrocarbon phase decreases drastically with the amount of dissolved supercritical fluid, which enables SCF mixtures to move freely in small pores and tiny structures, such as exist in oil shale. To date, $scCO_2$ has been successfully used to recover kerogen from oil shale in Queensland, Australia, and Raytheon has tested the use of $scCO_2$ in combination with radio frequency heating to extract shale oil in the Green River Formation in the USA. We are currently investigating the potential of $scCO_2$ for the economical extraction/displacement of petroleum from large untapped oil-shale resources in New Brunswick (Canada) and elsewhere. Future plans include investigating the utility of $scCO_2$ as a solvent and thermal transfer agent for the extraction of oil from the shale; supplemental heating of $scCO_2$ using microwave and sonochemical energy in situ; and potentially improved permeability in resultant oil-stripped residual powder.