18.18 **Extraction of hydrocarbons from oil shale using sub-critical water**

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Sub-critical water extraction is being developed as a more environmentally-friendly approach to oil shale processing. The large ionization constant and high density of sub-critical water gives it solvent properties comparable to organic liquids as well as acid-base catalytic function. The hydrocarbon extracting tendency from Huadian (China) oil shale by sub-critical water was studied using a 1-L, high temperature and high pressure reactor. The temperature and pressure ranges used during extraction experiments were 260°C-300°C and 5-15 MPa, respectively. The effects of temperature, and pressure on the extraction of hydrocarbons were assessed. The solid, liquid and gas phase samples were collected and characterized after extraction experiments. The shale oil yield at 260°C and 15 MPa was 45 wt. % of the Fischer Assay yield. The results of thermogravimetric analysis showed that the weight loss of residual solid samples was much smaller than that of the original oil shale, indicating that kerogen components were decomposed by treatment with sub-critical water. GC-MS showed that there were more than 300 recognizable peaks in the extracting solution following processing at 330°C and 18 MPa. In addition to a large number of hydrocarbons, the chromatograms had peaks representing many ring ketone, indenone, thiophene, and phenol derivatives as well as other heteroatom and aromatic compounds. A further indication that large amounts of high molecular weight hydrocarbons decomposed was provided by the increase in the types and concentrations of polycyclic and heterocyclic compounds generated at higher pressures and temperatures. It was inferred that sub-critical water was capable of cracking kerogen molecules into smaller hydrocarbon compounds at relatively low temperatures. This approach foregoes the need to use organic solvents or other reagents in oil shale extraction and is therefore proposed as a “greener” way of processing oil shale.