Novel process for shale oil upgrading without using hydrogen

John Gordon, Mukund Karanjikar, Javier Alvare, Dennis Larsen

Ceramatec Inc, USA

Catalytic hydrotreating of oil suffers from high consumption of hydrogen, undesirable saturation of organics and poisoning of catalysts. Alternatively, petroleum crude upgrading in the presence of hydrogen and molten sodium has been demonstrated in the past. However the primary challenge has been economic recovery and recycle of sodium. Moreover, such a process was not investigated for shale oil. The purpose of the project is to develop an economic upgrading technology for shale oil that utilizes sodium for removal of nitrogen, sulfur, and heavy metals and also efficiently regenerates the alkali metals via electrochemical method. The regeneration process currently utilizes a relatively low cost sodium conductive membrane to efficiently separate and recycle sodium. The methodology constitutes contacting of shale oil with sodium at high temperature and pressure in the presence of hydrogen or methane in a stirred tank reactor. Sodium reacts with sulfur and nitrogen to form sulfides and nitrides, which are separated and subjected to electrochemical conversion back to sodium and sulfur. Sodium is recycled to feed into the upgrading reactor. The shale oil samples before and after the reaction are analyzed using elemental analyzer (CHNS) for nitrogen and sulfur and Inductively Coupled Plasma (ICP) for measuring change in heavy metal concentrations (*e.g*. Hg, As, V, Cr, Fe, Ni). The oil is also analyzed using a Gas Chromatograph for boiling point distribution and aromatic content. Experiments were performed in triplicate. The results show that upgrading in the presence of sodium does not require hydrogen but instead can be achieved with methane. The results further indicate that 96.5% of sulfur and 97% of nitrogen were removed from shale oil using methane in the presence of sodium. Aromaticity of the shale oil is retained through the upgrading process. Use of hydrogen also produces similar results for nitrogen and sulfur removal. Economic recovery of sodium has been demonstrated. This prominent discovery provides a gateway to using lower cost sources of hydrogen in the upgrading process, eliminating the need for steam methane reforming (SMR). Furthermore, hydrogen is not available at small scales. The proposed process is modular in nature and thus suitable for operating on a field or at a refinery.