

Processing options for shale oil upgrading

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This paper presents attractive processing options for upgrading shale oil to both synthetic crude and finished products meeting ULSD and even Euro diesel specifications. The paper will primarily focus on the novel catalyst systems, processing schemes, and reactor designs developed based on our extensive research conducted over the last 30 years and pilot plant tests conducted recently in our labs to upgrade shale oil. Three processing schemes will be presented – **“Single Stage Once Through”, “Single Stage with Recycle” and our patented “Split Feed” hydroprocessing scheme. Operating conditions and process scheme are** selected based on the final upgrading objectives (synthetic crude, finished product, capacity, etc.). Shale oil requires particular attention to the high levels of contaminants present like arsenic, iron, nickel, and vanadium for designing the pretreatment section. An effective pretreatment offers longer operating factors for the downstream hydroprocessing reaction section. We have developed novel pretreatment catalyst and processing schemes to remove contaminants and address other problems associated with shale oil such as high chlorides, acidity, and oxygen. Many of the process concepts have evolved from the expertise we have in residue hydroprocessing and in hydrocracking for the production of middle distillates. The design parameters selected are based on our parent companies extensive research and data from our experience from the design of the world's first shale-derived naphtha hydrotreater which operated for 5 years and produced more than 900,000 bbl of naphtha meeting Jet A-1 specs. The hydrotreater used multiple reactors with specially tailored operating conditions and catalysts to prevent excessive fouling. Recently we have conducted pilot plant and micro-unit test for upgrading shale oil feed with extremely high levels of contaminants such as nitrogen (0.3-1.4 wt%), sulfur (0.2-9 wt%), oxygen (0.6-6 wt%), arsenic (2-17 wppm), chlorides, acid number, metals, and sometimes microfine ash.