Electrokinetic separation of metals and heteroatoms in asphaltenes

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As the world's reserves of light and medium crude oils are depleted, oil refineries are increasingly having to process heavy oils and bitumen. This implies the use of more complex and expensive methods to produce and process the products required. The presence of heteroatoms (such as nitrogen, sulfur, and oxygen) as well as metals (such nickel, vanadium, and iron) in heavy oils and residua reduces their value and refiners must resort to various expedients for removing heteroatom and metal containing compounds. For instance, conventional approaches to removing sulfur and its derivatives involve catalytic hydrogenation processes at moderate temperature and pressure conditions. However these processes remain a challenge today because asphaltenes are coke precursors in catalysts and can behave as catalyst inhibitors. Specifically, the metal and other heteroatoms present in asphaltenes tend to accumulate on catalysts and result in catalyst deactivation. Many attempts have been made for efficient upgrading of heavy distillate fractions that are technically viable. Yet they have limited application due, in large measure, to the high cost of the technology involved. Thus, efficient and more environmentally friendly processes that exploit molecular properties are needed in order to lower the energy intensity and improve the quality of feedstocks for product generation.

In this study, we propose to use electrokinetic phenomena for selective separation of polarizable particles of heavy feedstock, namely asphaltenes. The separation is based on differences in polarization characteristics of the different molecular components of asphaltenes as compared to other species in petroleum feedstocks. The motion of asphaltene particles subjected to a uniform electric field is investigated as a driving mechanism for separation of metals and heteroatoms from asphaltene solutions in toluene. To the best of our knowledge, electrokinetic separation of metals and heteroatoms by application of direct-current electric potential has not been attempted in the past. A second objective of this study is to better characterize the polarizable species in asphaltenes and shed light onto the interactions between these species and electric fields. The proposed separation method has the advantage of reducing metal and heteroatom content under atmospheric pressure and temperature conditions, thereby substantially reducing costs in the total processing and refining process..