Viscosity reduction of heavy oil through catalytic aquathermolysis at relatively low temperature

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The high viscosity of heavy oil often causes difficulties in its exploitation. Reducing its viscosity in oil layer is one of the most effective methods to enhance its recovery. As is known to all, the high viscosity of heavy oil is caused by its heavy components, asphaltenes and resins, and decomposing them is the unique effective way to achieve this aim. Therefore, it is important to understand how the asphaltenes and resins cause the high viscosity of heavy oil, and disrupting what kinds of actions can decompose them.

Catalytic aquathermolysis recovery is a great potential technology to enhance the recovery of heavy oil, reducing the viscosity of heavy oil to a large degree permanently in oil layer. The popular viewpoints show that the hydrodesulfurization is the main reason for viscosity reduction during this process, the high viscosity of heavy oil is due to the chemical actions caused by hetetroatoms Q (S, O and N), and breaking the C-Qs to remove these hetetroatoms is the key to reduce the viscosity permanently [1]. However, these changes always need high temperature which can not be reached in oil layer through current steam injection technology.

Our researches show the different findings [2]. The products of catalytic aquathermolysis at relative low temperature are small saturated and aromatic hydrocabons and hetetroatoms-containing compounds fragments, which is due to the disruptions not on strong covalent bonds C-Qs, but on mainly occur on the relatively weak actions such as van der Waals forces and hydrogen, ionic and coordinate bonds, the typical molecular structure of them are showed in Figure 1. This means the most important reaction is depolymerization of the firm associating supermolecules of asphaltenes and resins due to disruption of the relatively weak actions: van der Waals forces, hydrogen, ionic and coordinate bonds. which cause the large viscosity reduction. Obviously, these relatively weak actions play the leading role in the high viscosity of heavy oil.

In the supermolecular structure of asphaltenes and resins, the unit layers combined together through the associating actions of the conjugate big π bond of the aromatic core and the winding actions of the side-chains, and finally produce a large quantity of action points of van der Waals forces. Meanwhile, hetetroatoms and metals cause the hydrogen, ionic and coordinate bonds. It is the tremendous resultant force of these types of relatively weak actions that causes the large and firm associating supermolecule of asphaltenes and resins and finally leads to the high viscosity of heavy oil.

To further confirm the conclusion, we investigated the temperature-viscosity-relationship of heavy oil before and after catalytic aquathermolysis. The results show the relatively weak chemical actions are sensitive to temperature. They can form tremendous resultant force at low temperature, but nearly all of them can be disrupted simultaneously at not very high temperature. Therefore, only disrupting the weak actions in heavy oil can lead to its large viscosity reduction, needing not break the strong chemical actions at very high temperature.

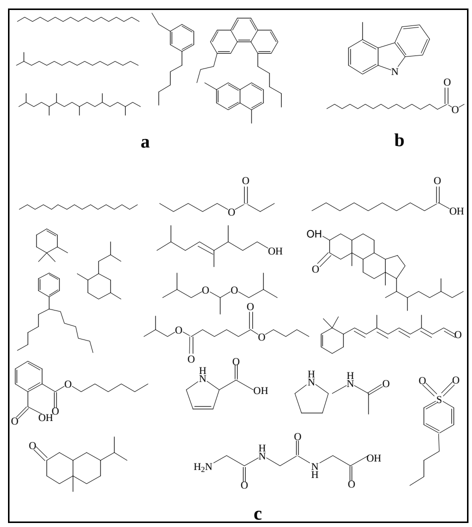

Figure 1 Typical molecular structures of the changed compounds during catalytic aquathermolysis: a, the increased compounds of saturated and aromatic hydrocarbons; b, the redistributed molecules in asphaltenes and resins; c, the increased compounds in reaction water and pyrolytic gas.

References

[1] Clark, P.D., Hyne, J.B., Tyrer, J.D. (1983) Fuel. 62,959-962.
[2] Wang, Y.Q., et al. (2010) Energy & Fuels. (as soon as possible).