

Comparing the Bulk Kinetic Parameters of Hydrocarbon Generation from Source Rock and Related Asphaltene

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Abstract

In order to compare the hydrocarbon generation kinetic parameters (E, A) of source rock and its related asphaltene, an immature core sample from Pabdeh Formation in Gachsaran oil field was studied. Artificial thermal maturation of source rock and its related asphaltene was performed by open-system pyrolysis (Rock-Eval) at three different heating rates of 5, 15, 25 °C/min. Subsequently, the kinetic parameters of the samples were optimized and determined using Optkin software. The difference in frequency factor values of the source rock and its related asphaltene is remarkable. However, the activation energy distributions of the studied samples are almost identical.

After determining the kinetic parameters of source rock and its related asphaltene, kinetic modelling of the samples was performed using PetroMod software. The temperatures of the onset (TR 10%) and the peak petroleum generation from studied samples were predicted by the kinetic models. Using an assumed geological heating rate of 1.5 °C/My, the onset of petroleum generation from source rock and its related asphaltene is predicted to occur at around 114 °C and 103 °C, respectively. On the other hand, the peak petroleum formation temperature (geologic T_{max}) is ~136 °C (TR 56.3%) for source rock, while it is ~132 °C (TR 57.75%) for related asphaltene.

Keywords: Gachsaran oil field, Pabdeh Formation, Rock-Eval pyrolysis, Asphaltene kinetics, Kinetic parameters, Kinetic modelling

Introduction

The organic matters present in sediments and sedimentary rocks are thermodynamically unstable at any subsurface temperature and pressure. Thus, they convert to more stable compounds such as kerogen, bitumen, hydrocarbons and finally residues through a succession of chemical reactions by increasing temperature while burial depth increases [1,2]. Approaching organic matters to the thermodynamic equilibrium that is associated with hydrocarbon generation is governed by non-isothermal chemical kinetics, because the

temperature varies during the time under geological conditions [3]. Chemical kinetics is a branch of chemistry which deals with the rate of chemical reactions [4]. The rate of most chemical reactions increases with an increase in temperature [5]. The chemical reaction of petroleum generation from organic matters follows this rule, too. For this reason, knowledge about the kinetics of hydrocarbon generation from source rocks is important for modelling and evaluation of generated hydrocarbons in sedimentary basins.

The reaction rate of kerogen conversion into hydrocarbons at a constant temperature can be expressed as the following equation:

$$dV / dt = k (V_0 - V_t)^n \quad (1)$$

Where V₀ is the initial concentration of reactant (kerogen); V_t is the concentration of generated hydrocarbons during the thermal degradation of kerogen and thus (V₀-V_t) indicates the remained concentration of kerogen; k is the reaction rate constant; and the exponent n represents the order of reaction. All chemical reactions involved in hydrocarbon generation from organic matter are considered as first order (n=1). Because of the occurrence of petroleum generation under non-isothermal conditions, the value of k in equation 1 is not constant [1]. The dependence of kerogen decomposition constant rate to temperature is given by the following equation, called the Arrhenius equation:

$$k = A \cdot e^{-E_a/RT} \quad (2)$$

Where A is the frequency factor (also called the pre-exponential constant), E_a is the activation energy, R is the gas constant (also called the ideal or universal gas constant), and T is the absolute temperature. E and A parameters can be found experimentally by pyrolysis of source rock at different temperatures and measuring the generated hydrocarbons [6,7].

Immature source rock or isolated kerogen samples are widely used in order to determine the hydrocarbon generation kinetic parameters [8]. Measuring the kinetic parameters using asphaltenes is also technically feasible [9]. The main goal of this study is determination and comparison of the bulk kinetic parameters (E, A) of source rock and