

Thermodynamics Of Drift Theory Of Fossil Fuel Production

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Abstract: The drift theory of fossil fuel production is associated with the plant material transported with stream of water from one place to another, and finally get deposited in a place of swamp having the suitable condition like sediments. The evidence of drift theory is provided by the sedimentary deposits of coal and other fossil fuels. To trace the origin of formation of fossil fuels in the earth's crust, we consider the application of laws of thermodynamics using the Hess's Law, Gibb's free energy, heat enthalpies, and particularly the deoxygenation parameters to study the transformation of plant materials into the fossil fuels. Here, I elucidate the concept of thermodynamics linked intricately with the development of fossil fuels and the phenomena of photosynthesis, a prerequisite in the thermal analysis of fossils.

Keywords: Photosynthesis, deoxygenation free energy, deoxygenation quotient, thermochemical, coalification, carbon content, standard enthalpy.

1. Introduction

Energy received from sun with the help of photosynthesis is stored chemically in the form of natural material and free O₂. As soon as a life forms dies, the biological matter is aerobically decomposed to not only the gases but also to other water-soluble compounds, and then refurnished back into the atmosphere. However, 0.1% does not undergo chemical and microbial oxidation, especially in the first few centimetres of burial layers but is subjected to anaerobic transformation into fossil fuels within sediments. As it gets accumulated over the time period, the total content of fossilized organic matter is always greater than the actual biomass and gives us a peek into the geological evolution of fossil fuels. Structure of basin and depth, along with the age and temperature are used to analyse the speed and chemical framework of the degradation of its biomass and its formation to fossil fuels. Consequently, recent investigators have received the result that the maturation process occurs rapidly. A new method to deduce of the amount of the heat used in the procedure of coal creation is argued and hence the situations that are then leading the gathering of fossil fuels. For a transparent understanding, we split the mechanism into three important parts as follows; heat enthalpy of coal formation, deoxygenation thermodynamic analysis and qualitative aspects. Throughout this paper, we mainly focus on the introduction of terms associated with the given spontaneity of the process. So, a sufficient clear-cut understanding is necessary on each fundamental step which will be discussed further. [1-3]

2. Heat Enthalpies of Coal Production

To evaluate the enthalpy of coal formation, we rely upon heat consumption in the process of coal formation, which reflects thermodynamic conditions of solid fuel formation in the deep interior of the earth, can be calculated if the heat (enthalpy) of fuel formation is known. This calculation is given below based on Hess's law, according to which the heat effect of reaction depends on only the initial and final states of the system and does not depend on intermediate states; this heat effect is the difference between the summation of the heat of formation of associated reaction products and the summation of the heats of formation of parent substances.

Based on the sequent of the first law of thermodynamics or the Hess law, a procedure is developed to calculate the heat enthalpy of coal formation by the formula introduced as:

$$Q_{fc} = \sum v_i Q_i - Q_i^{daf} \quad \text{kJ/kg}, \quad (1)$$

where Q_{fc} is the standard heat of formation of coal, kJ/kg; v_i is the stoichiometric coefficients of complete combustion of coal; Q_i are the standard heats of formation of combustion products from carbon, hydrogen, sulphur, and nitrogen, kJ/kg; Bychev and coauthors calculated the numbers of moles v_i of oxides formed upon the complete combustion of 1 kg of coal (daf), that is, stoichiometric coefficients.

Let us consider the elements carbon(C), hydrogen(H), oxygen(O), nitrogen(N), sulphur(S) that undergoes a transformation in solid fuel.

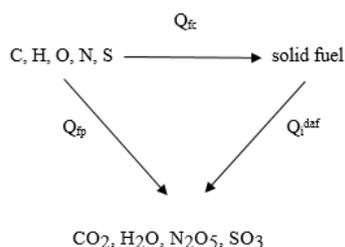


Figure 1: Hess's Law for Calculating heat (enthalpy) of formation of coal

According to Hess's Law from this diagram, we find that the heat enthalpy of formation of coal is given by:

$$Q_{fc} + Q_i^{daf} = Q_{fp} \quad (2)$$

$$Q_{fc} = Q_{fp} - Q_i^{daf} \quad (3)$$

It is well known that the process of coal formation depends on the following three factors: temperature, rock pressure, and geological time. Temperature is the most important factor. [2]

Now, in this manner we can know the production of fossil fuel from the heat enthalpy of the coal formation. Suppose, we know the heat of formation of wood and we need to evaluate the heat of formation of coal at any particular stage as a fossil fuel.

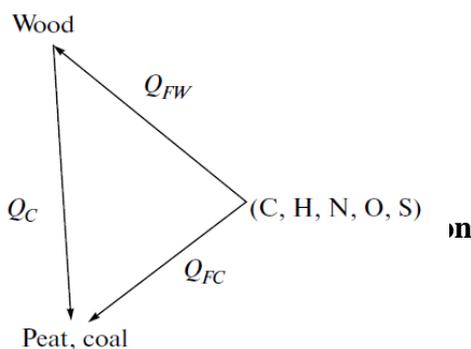


Figure 2: Basis for evalua

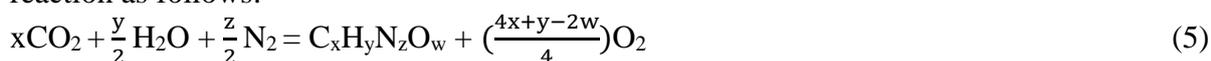
Consider the above diagram, as they can be calculated as:

$$Q_c = Q_{FC} - Q_{FW} \quad (4)$$

Thus, what we can infer from the above scenario is that to know the heat of formation of coal from its elements like carbon, oxygen, hydrogen, nitrogen and sulphur, we need a direction of flow of heat in a proper manner as shown. Heat is required for the formation of coal and the coalification is an endothermic process. It gives us the beauty of first law of thermodynamics. [4]

3. Deoxygenation Thermodynamic Analysis

In terms of drift theory, the most vital phenomena that comes to our perception is the transfer of energy from one point to another. Deposit if sediments on one hand has a mass transfer basis but what seems more convoluting is the fact of how energy is facilitated from one point to another in a geological environment. Here, comes the application of second law of thermodynamics which tells us about the entropy changes associated with the process. However, since production of fossil fuels is such a slow process that it is rather tiresome to evaluate the initial and final stages of the whole complex system, we rely on a simple concept of Gibb's free energy or more specifically the, deoxygenated Gibb's free energy. Conversion of organic remains to fossil fuels is seen as a process in which oxygen is removed from biological substances. The deoxygenation of compounds of the C, H, O, (N-S) system is initiated by the step wise natural processes of fundamental importance like photosynthesis and compaction of biological remains to fossil fuel formation. Greater is the degree of deoxygenation, higher is the outcome of caloric value of organic compounds. This underlying approach is made on the assumption that the isolation of oxygen during formation of fossil fuels happens via loss of H₂O and CO₂, a model depicted for coalification. It asserts the sporadic conversion of one organic substance into another after losing H₂O, CO₂, and N₂, then, calculating the Gibbs free energy necessary to remove 1 mole of oxygen in resulting compounds formed from CO₂, H₂O, and N₂ (if necessary), and the data is compared with theoretical free energy values. This free energy of reaction is coined as deoxygenation free energy, G_{deox} and can be calculated from the Gibbs free energy of reaction for this typical reaction as follows:



$$\text{as, } G_{\text{deox}} = \frac{4\Delta G_r}{(4x+y-2w)} \quad (6)$$

$$\text{and, } \Delta G_r = \Delta G_f^\circ(\text{C}_x\text{H}_y\text{N}_z\text{O}_w) - x \Delta G_f^\circ(\text{CO}_2) - \frac{y}{2} \Delta G_f^\circ(\text{H}_2\text{O}) \quad (7)$$

where G_f⁰ is the Gibbs free energy of formation for individual chemical species at 1 bar pressure and at a particular temperature.

Similarly, deoxygenation enthalpy, H_{deox} may be defined on the basis of equation (5) as:

$$H_{\text{deox}} = \frac{4\Delta H_r}{(4x+y-2w)} \quad (8)$$

$$\text{and, } \Delta H_r = \Delta H_f^\circ(\text{C}_x\text{H}_y\text{N}_z\text{O}_w) - x \Delta H_f^\circ(\text{CO}_2) - \frac{y}{2} \Delta H_f^\circ(\text{H}_2\text{O}) \quad (9)$$

where ΔH_f⁰ is the enthalpy of formation.

Now, we introduce another term that will help us to point at the analysis of fossil fuel production known as deoxygenation quotient, Q_{deox} which relates the G_{deox} or H_{deox} values of various compounds to the amount of deoxygenation, which is a clear-cut measure of ageing of fossil fuels.

$$\text{Mathematically, } Q_{\text{deox}} = \frac{4x+y-2w}{4x+y} \quad (10)$$

The equations (8), (9) and (10) form the basis of assessment of fossil fuel production from a given parent material.

The significance of the G_{deox} versus Q_{deox} relations concerning the conversion of vegetal substance to fossil fuels is obvious when we focus that generally, the photosynthetic products have much higher G_{deox} but have lower Q_{deox} values if we compare them with fossil fuel substances. Higher G_{deox} signifies that more energy is chemically stored in releasing a single unit quantity of O_2 from a mixture of H_2O , CO_2 , and N_2 , and also that a substance could be deoxygenated spontaneously by expulsion of CO_2 and H_2O to produce another substance having lower G_{deox} . Flow of energy is governed by this fact. [5-7].

4. Qualitative Aspects

One can infer from the above thermodynamic analysis of fossil fuel formation that the favourable parameters for the conversion of plant material into the fossil fuels must be that the large positive G_{deox} values for all organic materials composed of C,H,N and O as chief elements indicate removal of oxygen from system is precursor to the fossil fuel formation. This establishes the second law of thermodynamics. For instance, cellulose a material in wood has G_{deox} value around 478.5kJ and methane which has the low G_{deox} (409.0 kJ) among organic substances. The hydrocarbons we often come across in nature have G_{deox} less than 427.2 kJ. Higher the temperature is (say up to a few hundred $^{\circ}C$) lesser is the impact on energy relation changes, but they surely effect the reaction rates, which grows exponentially according to the Arrhenius equation, $k = Ae^{\frac{-E_a}{RT}}$ where E_a is the activation energy and k , the rate constant. Because the spontaneity of evolution of fossil fuels is witnessed at even room temperatures but a completely isolated system, on the other hand, may not favour formation of fossil fuels [8-12].

5. Conclusion

At this point, I would ascertain to the fact that this paper is a gateway to the broad outlook on the production of fossil fuels governed by laws of thermodynamics and a brief source of insight into the possible theories and experimental results to explain the much wider scope of discovery of alternative for fossil fuels with statistical tools and using concepts of evolution of energy sources. It is unclear yet opens a new door of plausible explanations in the coming future.

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