LIQUID FUELS FROM COAL
STUDIES OF SOME REACTIONS TO INCREASE THE HYDROGEN/CARBON RATIO

R.L. KALRA

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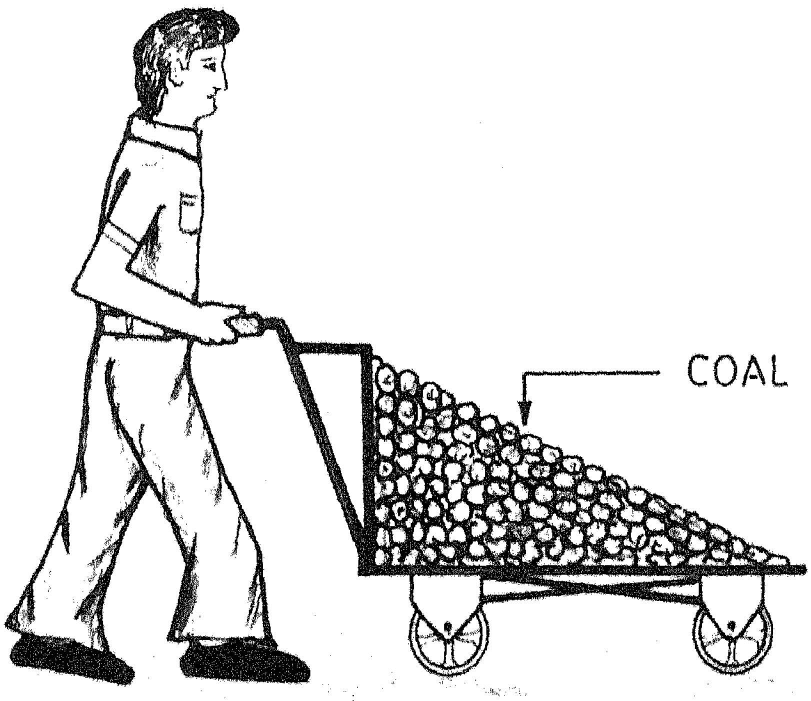
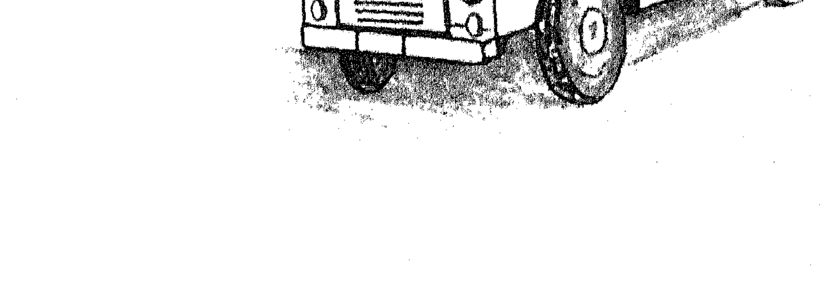

COAL


LIQUID
FUEL

CERTIFICATE

This is to certify that the thesis entitled 'LIQUID FUELS FROM COAL' (STUDIES OF SOME REACTIONS TO INCREASE THE HYDROGEN/CARBON RATIO) being submitted by Mr.R.L.Kalra to the Indian Institute of Technology,Delhi, for the award of the degree of Doctor of Philosphy, is a record of the bonafide research work carried out by him. Mr.R.L.Kalra worked under our guidance for the submission of this thesis which to our knowledge has reached the requisite standard.

The thesis or any part thereof has not been submitted to any other University or Institute for the award of any degree or diploma.

3/5/82
Dr.M.K.Sarkar
Professor,
Chemical Engineering
Department

Ratna Choudhury
3.5.82
Dr.(Mrs.)R.Choudhury,
Lecturer,
Centre of Energy Studies,

Indian Institute of Technology,Delhi
New Delhi-110016.

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RLKalra
(R. L. Kalra)

ABSTRACT

In the present energy crisis, liquefaction of coal assumes considerable significance in all research centres of the world. The present thesis records various means of bringing coal into the liquid form. These are, solubilization of coal by solvent extraction, solvent extraction with superimposed chemical reaction, alkali degradation followed by solvent extraction and alkali degradation followed by hydrogenation respectively.

Though these methods have been worked out earlier, a new dimension has been given to the line of attack by conducting the solvent extraction experiments at the plastic state temperature of the particular coal. It is proposed that at the plastic state temperature, the coal complex is in a semi solid flowing form and therefore most vulnerable to attack by solvents. Schematic solvent coal-particle interaction has been put forward to show that at the plastic state temperature coal particle gradually shrinks by a peeling off mechanism when going into solution. The semi solid form of coal consists of

solid particles and entrapped low boiling liquids. The solvent acts by dissolving the entrapped liquid in liquid phase reactions and by carrying it bodily in vapour phase extractions. In both ways some of the coal has been liquefied and it enhances the calorific value of the solvent. A noval alkyl group transfer mechanism has been discovered in reactions of coal with molten alkali in liquid paraffin medium (which consisted of aliphatic hydrocarbons). A schematic reaction showing the probability of liquid paraffin acting as an alkyl group donor has been proposed. This angle opens up an avenue where petroleum wastes could be used in the liquefaction of coal. In other words it amounts to the using of wastes of one industry as feed for another.

Alkali degradation has been explored with the idea of breaking down the coal complex into simpler fragments of lower molecular weight. Since the essence of coal liquefaction lies in the increase in hydrogen by carbon ratio, hydrogenation or hydrocracking is a necessary step. Hydrogenation would involve high pressure and therefore high cost. Hydrocracking would requi coal liquids as the starting materials. If the coal complex could be broken down to smaller fragments by simpler methods probably the hydrogenation would be feasible under less severe conditions.

This appeared very likely because model compounds having similar molecular weights could be hydrogenated easily at lower pressure. Therefore alkali degradation reaction with molten alkali was conducted in a vehicle whose boiling range fell in the plastic range of the particular coal. With alkali degraded coal, hydrogenation, with hydrogen gas and a suitable catalyst could be carried out at a much lower pressure at 20-25 atmospheres. Various catalysts have been used. Souble catalysts have also been used as these could find their way into the coal structure and cause rupture of the coal complex by adsorbing hydrogen at much faster rate. The H/C of the coal was raised as expected but the percentage extraction was not drastically enhanced. Solubility of the degraded coal and hydrogenated coal were enhanced in comparison to original coal in solvents like pyridine and quinoline. Increase in solubility could be taken as a direct function of simplification of structure. Similarly the extent of alkylation was evaluated from increase in solubility upto 15% and increase in H/C from 0.89 of original coal to 1.29 of treated coal residue respectively. Addition of hydrogen or alkyl groups have also been traced in the infrared spectra.

The general conclusion based on this work is that coal once reduced to smaller fragments by alkali degradation, could be hydrogenated under less severe conditions of pressure and temperature. It could also be dissolved easily and subjected to hydrocracking. Oxidative degradation helped in depolymerisation of the coal structure and increase in volatile matter in the coal residue.

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CHAPTER-6 HYDROGENATION