STUDIES IN THE FIELD OF

FUEL ALTERNATIVES

A THESIS

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By

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F U E L A L T E R N A T I V E S

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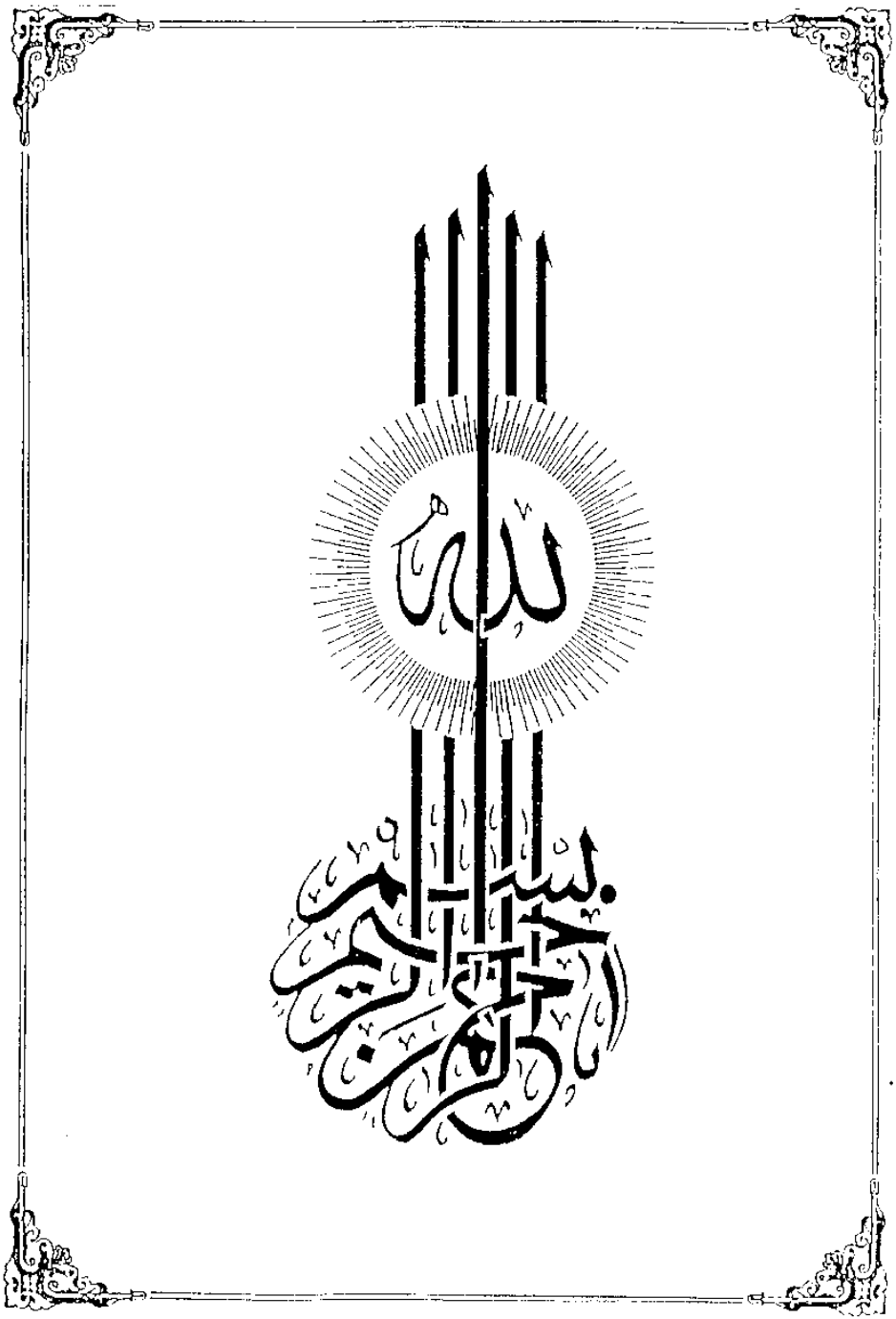

C O N T E N T S

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PART TWO: STUDIES ON THE SACCHARIFICATION OF SOME EGYPTIAN CELLULOSIC WASTES.

S U M M A R Y

SUMMARY

It is well known that the fossilized fuel (oil, coal and gas) will be depleted. In fact, it is predicted that the oil will be exhausted in Egypt in the near future, approximately 10 years. On the other hand, the world supply of caol may be expected to continue for several hundred more years (cf. Fig. 1).

However, there are constraints on the use of coal as a source of energy. The first principal constraint is the rise of the CO_2 level and as a consequence, the surface of the earth is heated up and climatic changes will occur (cf. Fig. 4). The second constraint is that the result of burning coal is the production of benzo(∝) pyrene which is a very powerful carcinogenic substance, and one of the principal causes of lung cancer.

Nuclear, geothermal and hydroelectric powers are very important energy alternatives, but finding a liquid fuel which can be used in the internal combustion engines, is a vital and important matter.

Here comes the role of biomass (biological mass) for the production of liquid fuels instead of petroleum and diesel.

From biomass liquid fuel producing point of view, the world can be divided into three categories:

1- Ethanol producing countries: where land, water and climate are favorable to produce sugar-cane or cassava that can be hydrolyzed to glucose, then fermented to produce ethanol. As example in this field is in Brazil, where the alcohol is used to blend with petrol up to 20%, and no adjustment to the engine is required. Besides, many cars run with ethanol only.

2- Methanol producing countries: where forests are available to convert the wood into methanol, which is an excellent fuel and does not need any change in the motor's engines.

3- Desert areas: which have neither enough water, nor fertile land and forests. This is the case in Egypt.

In this case, these desert lands should be used in planting desert plants that fix the solar energy to hydrocarbons. The advantage of these plants is that they resist the drought and do not need much water.

The aim of the present work, in Part I of this thesis is to search for some desert plants that produce hydrocarbons. In Part II of this thesis, the author tried to find enough cellulosic wastes to be converted to glucose which can be fermented to ethanol for use as liquid fuel.

The study of the hydrocarbon producing plants began seriously from 1977 in the U.S.A. by Professor

M. Calvin (Nobel prizer in Chemistry), he studied about eighteen species of the Euphorbiacea family (there is about 2000 species of this family). Two species have been selected for experimental plantations:

1- E. lathyris, an annual plant from seeds.

2- E. tirucalli, a perennial plant from cuttings.

The estimated cost price was about $20 for each barrel. This estimation was carried out on wild versions of plants.

In our experiment, the seeds from E. lathyris were provided by Professor Calvin and the cuts of E. terucalli were imported from Kew Gardens, London. They have been cultivated in the Chemistry department, University College for Women, Ain Shams University, Cairo.

Also, with the collaboration of the Egyptian Desert Institute, systematic searches for indigenous species of latex producing plants have been carried out.

Since the aim of this study was to evaluate the hydrocarbon content of different species to choose the most efficient one, it was necessary to select species that can be put in some program to produce hydrocarbons economically, under drought and salinity conditions.

The species have been selected from the

Euphorbiaceae family which are E. nerrifolia, E. abyssinica, E. Royleana, E. lactea, E. pseudocactus, E. nubica, E. mauritanica, E. grandicornis, E. pulcherima, Synadenium granti (cf. Figs. 19, 20, 21), and from the Asclepiadaceae family Calotropis procera.

The chemical study of these plants is divided into two stages. The first one is the extraction of the chemical content of the dry plant by means of the polar and nonpolar solvents, and then the determination of the percentage of each extraction and their carbon/hydrogen content and also the study of their i.r. spectra.

The dry plants have been extracted by soxhlet technique using petroleum ether 60-80° for eight hours and then methanol for eight hours also.

The plants which have been studied were E. lathyris, E. mauritanica, E. lactea, E. nerifolia, E. nubica, E. pseudocactus, Synadenium grantii and Asclepiadacea calotropis procera.

For the E. lathyris, it was found that the extracted product from the nonpolar solvent was 4-5% of the dry weight. However, its carbon-hydrogen content was 79.9%, while that from the polar solvent was found to be 10.12% of the dry weight and its carbon-hydrogen content was 24.9%.

For the E. lactea, the extracted product from the nonpolar solvent was 6.5% of the dry weight, and its carbon-hydrogen content was found to be 88.48%, while that from the polar solvent was found to be 10% of the dry weight and its carbon-hydrogen content was 31.88%.

The E. mauritanica petroleum ether extract was found to be 5.13% of the dry weight, and its carbon-hydrogen content was 86.88%, while the methanol extract was 6.8% of the dry weight and its carbon-hydrogen content was 47.44%.

In the case of E. neriifolia, the petroleum ether extract was 7.2% of the dry weight and its carbon-hydrogen content was 80%, whereas its methanol extract was 12.8% of the dry weight, having a carbon-hydrogen content of 39.5%.

For the E. nubica, the resulting extracted product from petroleum ether was 7.5% of the dry weight, and its carbon-hydrogen content was 81.7%, while that resulting from the methanol was 8.3% of the dry weight and its carbon-hydrogen content was 44%.

However, the petroleum ether extract of the E. pseudocactus was 10.8% of the dry weight, having a carbon-hydrogen content of 81.5%, while that of methanol was 18% of the dry weight, and its carbon-hydrogen content

was found to be 23.7%.

For the synadenium grantii, the extracted product from petroleum ether was 10% of the dry weight and its carbon-hydrogen content 84.3%, while that extracted with methanol was found to be 15% of the dry weight and its carbon-hydrogen content was 33.5%.

Finally, for the Asclepiadacea calotropis procera, the petroleum ether extract was 5% of the dry weight and its carbon-hydrogen content was 80.73%, while its methanol extract was found to be 6% of the dry weight, having a carbon-hydrogen content of 30.1%.

It is clear that the methanol extraction is more efficient than the petroleum ether one; however, the opposite was true for the carbon-hydrogen content, as the percentage was as twice as much in the petroleum ether extract.

The infra-red study of the extracted products from all plants showed the presence of ν_{OH}, $\nu_{C=O}$ and ν_{CH} at (3400-3450), (1730-1740) and (2920-2845), cm^{-1}, respectively.

From the previous investigation, the imported E. latnyris and the local E. mauritanica and E. lactea proved to have the highest value of carbon-hydrogen content in their petroleum ether extract. So, we have measured their nuclear magnetic resonance for the

extracted products, which showed that there was no absorption in the aromatic region, and that the hydrocarbons present are of aliphatic nature, (δ between 0.7 and 1.6 ppm), (cf. Figs. 38 , 39 , 40).

The catalytic cracking of the E. lactea and E. mauritanica was carried out using aluminium oxide. The products were separated by G.L.C., their infra-red spectra and their calorific value were determined. The apparatus used in the catalytic cracking is shown in Fig. 41.

In case of E. mauritanica, the result from the catalytic cracking of the petroleum ether extract consisted of two products: one separated below 250°C (low yield) and the other between 250 and 450°C (higher yield), the G.L.C. of this product is shown in Fig. 45 and its calorific value was 10.26 Kcal/gm.

As for the E. lactea, the G.L.C. of the product resulting from the cracking process between 250 and 450°C is shown in Fig. 48 . The calorific value of this product is 10.11 Kcal/gm.

From the previous chemical study, E. mauritanica proved to be a very good candidate, and further investigation is carried out to test the effect of sea water irrigation and of etherel'c (growth regulator) on its hydrocarbon content.

Four different concentrations of sea water were

used in the investigation; fresh water - 25% sea water + 75% fresh water - 50% sea water + 50% fresh water, and 75% sea water + 25% fresh water. After six months, the plants irrigated with 50% sea water showed a clear increase in the petroleum ether extract, and also a higher carbon-hydrogen percent. At high dilution (75% sea water), a visual shrinkage was observed. The plants irrigated with 25% and 50% sea water gave new growths, but relatively less than that irrigated with fresh water.

Six months later, the plants irrigated with 75% sea water died. As for the two other dilutions, the yields of both the petroleum ether and the methanol extarcts have decreased, but still they are higher than the control experiment. The carbon-hydrogen percentage in the petroleum ether fraction of the plants irrigated with 50% sea water is the highest one.

The study on the effect of etherel'c, which is used to increase the hydrocarbon content at the expense of the vegitative part, was caried out using four different concentrations, 250 ppm, 500 ppm, 1000 ppm, and 2000 ppm.

After one month, the petroleum ether content of the plants sprayed with 1000 ppm has increased. Another month later, a clear decrease in the petroleum ether extract is observed; however, the carbon-hydrogen