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STUDIES ON THE MANUFACTURE OF AVIATION GASOLINE BY HIGH PRESSURE HYDROCRACKING OF SOYA BEAN OIL

by

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Research Period: Jan.-Aug. 1945

Prepared for and Reviewed with Authors by the
U.S. Naval Technical Mission to Japan

Dec. 1945

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LIST OF TABLES AND ILLUSTRATIONS

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SUMMARY

~~The object of this project was to determine the optimum~~ operating conditions in the hydrocracking of soya bean oil for the manufacture of high octane aviation fuel. It was found that by hydrocracking soya bean oil over MoS_3 catalyst at 1.0 space velocity, 200 kg/cm² hydrogen pressure, and temperature of 420-450°C., an aviation gasoline was obtained in 40% yield, which had an octane number (with 0.15% lead) of 80-85.

I. INTRODUCTION

This project was started in January 1945 in order to obtain an additional source of high quality aviation fuel. No previous reports or data were available on this subject.

In order to find comparatively good conditions for hydrocracking soya bean oil, experiments were first made in small autoclaves of 2-5 liters capacity. Molybdenum sulphide, (MoS_3), was selected for use in the pilot plant after testing several catalysts, including molybdenum oxide (MoO_3), nickel oxide (NiO), tungsten oxide (WO_3) and copper oxide (CuO). The optimum reaction temperature and hydrogen pressure were determined to be in the range of 420-450°C and 200 kg/cm², respectively. Next, experiments were performed in the small scale, continuous type pilot plant. The pilot plant used was the same as that described in the authors report on the hydrocracking of pine root oil. Although many unsolved problems still remain, the results are given in the following paragraphs

II. EXPERIMENTAL RESULTS

Properties of the raw material are tabulated below:

Specific Gravity d_4^{15}	0.9204
Boiling Point °C	300-320
Iodine Value	109.45
Saponification Value	165.31
Fraction Distilled at 300°C%	14.5

Records of experimental data obtained on autoclave scale were destroyed in August 1945. Pilot plant data are summarized in Tables I(B)18 and II(B)18.

The main problem in this process was to discover the best catalyst capable of producing aviation gasoline with at least 91-95 octane number. Various additional catalysts were subsequently tested on autoclave scale, including Cr_2O_3, Fe_2O_3, FeS, VO_2, TiO_2, and their mixtures, but only with TiO_2 catalyst was it possible to produce a superior gasoline with an octane number of 87. Pilot plant tests were made on MoS_3, which was the best known prior to discovery of the TiO_2, but it had a short life and produced a lower octane gasoline.

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III. CONCLUSIONS

An aviation gasoline of sufficiently high octane number could not be obtained from soya bean oil by means of high pressure hydrocracking with MoS_3 catalyst. The most important problem for future study is the discovery of a more active catalyst for this type of hydrocracking. Because soya bean oil is composed of long paraffinic chains having many unsaturated double bonds, it is possible to convert it into iso-paraffinic or naphthenic hydrocarbons with high octane value. Therefore it is believed desirable to continue this study, putting stress on catalyst investigations. As a result of these experiments, it was shown that an aviation gasoline of 80-85 octane number (0.15% lead) could be obtained in yield of about 40% from raw soya bean oil under reaction conditions of 200 kg/cm^2 hydrogen pressure, temperature of 420-450°C and space velocity about 1.0 over MoS_3 catalyst.

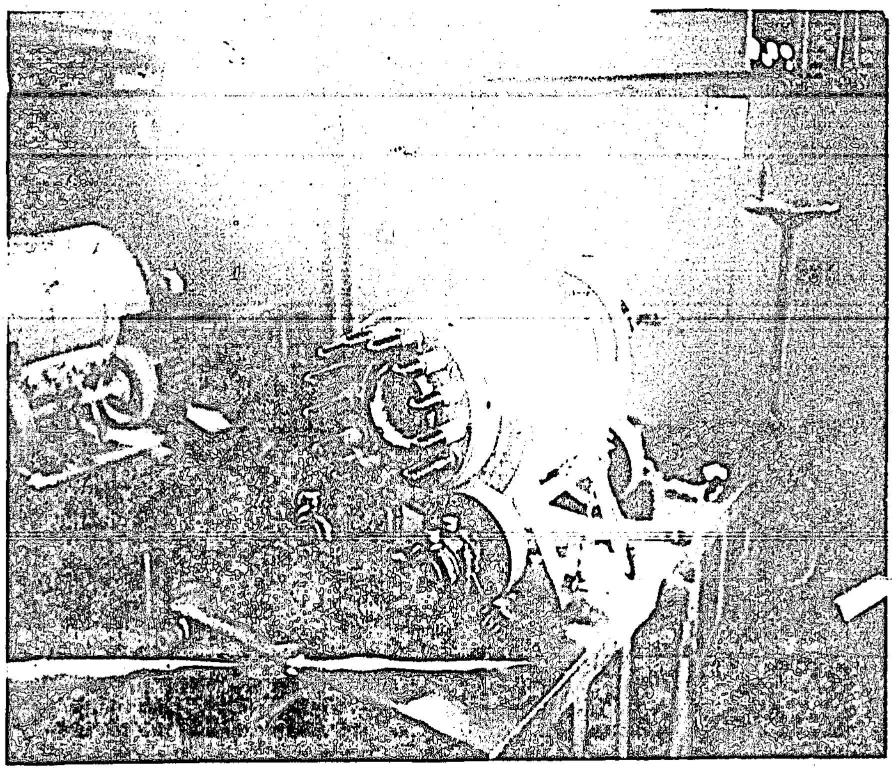

Figure 1(B)18
AUTOCLAVE (51) USED IN THE CRACKING OF SOYA BEAN OIL

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Table I(B)18

REACTION CONDITIONS & YIELDS
(Pilot Plant Test Data)

		Run No.			
		1	2	3	4
Reaction Conditions	Catalyst	MoS_3	MoS_3	MoS_3	MoS_3
	Reaction Temperature °C	420	430	450	470
	Preheaters Temperature °C	300	300	300	300
	Reaction Pressure kg/cm²	200	200	200	200
	Charged Oil lit/hr	2.89	2.88	2.93	3.05
	Total Charged Oil lit	23.17	5.77	17.59	24.40
	Charged Hydrogen Gas m³/hr	3.29	3.12	3.44	3.11
	Total Charged Hydrogen Gas m³	26.36	6.24	20.64	24.93
	Space Velocity (Liquid)	1.0	1.0	1.0	1.0
	Run Length hrs.	8	2	6	8
Products	Total Liquid Products lit.	22.27	5.82	14.80	17.32
	Liquid Products lit/hr	3.22	2.91	2.46	2.16
	Total Discharged Gas m³	15.39	4.16	13.38	16.12
	Discharged Gas m³/hr	1.94	2.08	2.26	2.01
	Water-wt% of Charged Oil	1.71	1.16	2.42	2.06
	Absorbed H_2-wt% of Charged Oil	5.68	4.56	5.42	4.81
	Yield-wt% of Charged Oil	78.6	82.4	65.6	56.2
	Yield-vol% of Charged Oil	96.1	100.0	84.1	70.9
Cracked Oil	Acidic Matter in Cracked Oil Vol%	2.0	0	0	0
	Iodine Value (I. V.)		12.17	6.97	19.16
	Saponification Value (S.V.)		0.536	1.369	0.699
	Specific Gravity (S.G.) d^{15}_4	0.7566	0.551	0.7200	0.7326
	Initial Boiling Point (I.B.P.) °C	43.5	40.5	34.0	39.0
	10% Boiling Point °C	93.0	71.5	58.5	65.5
	20% Boiling Point °C	126.2	94.5	74.5	91.0
	30% Boiling Point °C	165.0	119.0	89.0	109.0
	40% Boiling Point °C	222.2	148.0	90.6	136.0
	50% Boiling Point °C	270.2	188.0	128.0	170.5
	60% Boiling Point °C	296.0	234.5	158.5	215.0
	70% Boiling Point °C	304.2	292.5	210.0	274.0
	80% Boiling Point °C	309.5	306.0	270.0	303.2
	90% Boiling Point °C	318.0	313.0	308.0	316.0
	Final Boiling Point (F.B.P.) °C	343.0	336.0	311.0	334.0
	Total Distillate Vol%	97.0	96.5	95.0	94.0
	Residue Vol%	0.5	1.5	1.35	0.8
	Loss Vol%	2.5	2.0	3.65	5.2
Residual Gas Composition	CO_2 Vol%	0.1	0.2	0.1	0.2
	O_2 Vol%	0	0.1	0.1	0.3
	C_nH_{2n} Vol%	5.9	5.6	5.0	4.8
	CO Vol%	0.2	0.2	0.3	0.2
	H_2 Vol%	81.2	12.0	78.9	78.8
	n. (Carbon Number)	0.6	0.7	0.6	0.5

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Table II(B)18

PROPERTIES OF AVIATION GASOLINE PRODUCED
(Pilot Plant Test Data)

		Run No.			
		1	2	3	4
Reaction Conditions	Reaction Temperature °C	420	430	450	470
	Specific Gravity (S.G.) d_4^{15}	0.7030	0.6916	0.6910	0.6901
	Acidic Matter in Aviation Gasoline Vol%	0	0	0	0
Fractional Distillation	Initial Boiling Point (I.B.P.) °C	39.0	45.0	39.0	40.0
	10% Boiling Point °C	67.0	65.0	59.0	59.0
	20% Boiling Point °C	77.0	75.0	72.5	66.5
	30% Boiling Point °C	88.5	85.5	81.5	74.2
	40% Boiling Point °C	98.4	94.0	90.0	78.0
	50% Boiling Point °C	107.6	102.0	98.0	89.0
	60% Boiling Point °C	119.0	111.0	109.0	99.0
	70% Boiling Point °C	129.0	120.0	120.0	107.0
	80% Boiling Point °C	139.9	131.0	133.0	121.0
	90% Boiling Point °C	156.8	145.5	155.5	132.2
	97% Boiling Point °C	185.0	170.0		
	Final Boiling Point °C	188.0	185.5	177.0	164.0
	Total Distillate Vol%	97.4	98.0	93.0	95.0
	Residue Vol%	0.12	0.6		1.0
	Loss Vol%	2.48	1.4		4.0
	Yield-Vol% of Cracked Oil	31.7	48.0	64.9	51.0
Composition	Unsaturated Hydrocarbon (U.) Vol%	0	4.0	0	0
	Aromatic Hydrocarbon (A.) Vol%	6.0	8.0	16.0	8.0
	Naphthenic Hydocarbon (N.) Vol%	6.0		7.8	14.4
	Paraffinic Hydrocarbon (P.) Vol%	88.0	88.0	76.2	77.6
	Aniline Point (A.P.) °C	68.1	71.1	67.2	65.3
Octane Number	Clear	59.1	58.0	60.3	62.3
	With 0.15% of Lead	83.0	83.4	85.3	85.4