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Quarterly Report No. 3
Copy No. 09

⑥ A Study of the Decomposition Mechanism of
Ammonium Perchlorate

Prepared by: ~~Departments of Chemistry and~~
Chemical Engineering
⑥ Auburn University

For the Period: 1 Oct ~~1964~~ - 1 Jan ~~1965~~

⑥ Contract No. DA-01-009-ORD-1023(Z), ~~Part I~~
Birmingham Procurement District,
U. S. Army.

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Quarterly Progress Report No. 3

Birmingham Ordnance Contract DA-01-009-ORD-1023(Z), Part I,
entitled "A Study of the Decomposition Mechanism of Ammonium
Perchlorate".

For the period: 1 Oct. 1964 - 1 Jan. 1965.

1. During the period of this report ~~our~~ efforts continued with
the making of differential thermal analysis (DTA) runs at
various heating rates on ammonium perchlorate (AP) samples,
where the samples were of various particle size, shape and
either pure or contained selected additives.

A total of ~~one hundred and eight~~ DTA plots were made either
on new specimens or for rechecking values recorded in Quarterly
Report No. 2. Certain of these DTA runs were made with the
sample under pressure of nitrogen gas to minimize the sublimation
tendency of the AP.

2. The experimental techniques and equipment used were the same
as described in ~~our~~ previous report, except that we ~~began mixing~~
very fine glass beads with the AP material. By using a smaller
AP sample, the heat changes of the sample reaction do not
influence the results as markedly and hence allow the temperature
measuring devices to more accurately indicate the true
temperature being experienced by the sample.

Glass beads were selected for the diluting of the material
since they are non-conductors for electrons and should show no
catalytic influence on the AP decomposition. In all cases we
mixed the AP and glass beads in a 1:3 weight ratio.

The glass beads were Sign Beads, type 831A, Size B, wide
angle and manufactured by Flex-O-Lite Manufacturing Company
of St. Louis, Missouri.

Before being used the glass beads were washed with 3 normal hydrochloric acid solution, rinsed with distilled water and oven dried at 105 degrees C.

A DTA run on the glass beads alone vs. the alundum reference indicated that they underwent no changes over the 25 to 450 degrees C. temperature range that could product exo- or endo-thermic peaks on the DTA plot.

3. Some of the results reported in Quarterly Report No. 2 were based upon too few determinations. In order to increase the reliability of the calculations, the following runs were made, consequently, the following data should be added to:

(A). Table IX of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-29-1	0.1975	248.9	2.11	-11.769
2-29-2	.2011	255.1	4.16	-11.113
2-30-2	.2034	255.8	10.30	-10.213
2-31-3	.2006	254.0	10.13	-10.219
2-32-1	.1989	258.7	9.87	-10.263
2-33-1	.1968	246.2	2.11	-11.760

(B). Table X of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate} / T_m^2)$
2-31-2	0.2006	311.0	9.63	-10.475
2-32-1	.1989	318.7	9.36	-10.530

(C). Table XI of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$

2-29-1	0.1975	439.3	2.13	-12.380
2-29-2	.2011	459.9	3.83	-11.851
2-30-2	.2034	462.2	8.64	-11.044
2-31-3	.2006	453.5	10.00	-10.874
2-32-1	.1989	458.0	8.15	-11.091
2-33-1	.1968	443.0	2.25	-12.336

(D). Table XII of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$

2-30-1	0.2017	242.4	2.13	-11.737
2-31-1	.2005	248.9	4.47	-11.021
2-31-2	.2014	267.7	9.87	-10.300

(E). Table XIII of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$

2-31-2	0.2014	327.1	8.99	-10.601

4. Erratum.

In Table XIII of Quarterly Report No. 2 the peak temperature for sample 2-25-2 should read 304.5 vice 343.0. The remaining terms in this horizontal line should be changed to $OK = 577.7$; $T_m^2 \times 10^{-5} = 3.24$; $\text{Rate}/T_m^2 \times 10^5 = 1.260$; $1/T_m \times 10^3 = 1.732$; $\ln(\text{Rate}/T_m^2) = -11.270$.

5. In Table XVIII of Quarterly Report No. 2 for sample - Fine AP, peak No. 2, the slope has been computed to be -15.84×10^3 and the activation energy therefore is 30.46 kcal./mole.

6. In order to minimize the tendency of the AP sample to sublime from the hot to the cooler portion of the sample tube, DTA determinations were conducted under a nitrogen atmosphere where the pressure was maintained at 60 mm. of Hg in excess of atmospheric pressure.

The DTA plots showed three peaks. Peak 1 is the endotherm associated with the change in crystal structure. Peak 2 and 4 (we use 4 instead of 3 for designating this peak so as to indicate that it is the same peak so numbered on the DTA plots run against air pressure and shown in Fig. 4 of Quarterly Report No. 2) are the low and high temperature exotherms.

In the following tables are recorded the results of these runs and the last table summarizes the slope of the curves plotted from these data as well as the calculated activation energies.

Table 6-1

Material - Fine AP; Peak No. 1

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-40-2	0.2010	247.8	4.47	-11.014
2-41-1	.2014	246.6	2.34	-11.657
2-41-2	.2034	247.7	10.10	-10.274
2-61-1	.1989	244.2	2.10	-11.756
2-62-1	.2006	257.2	9.20	-10.328
2-62-2	.2003	250.5	4.20	-11.087

Table 6-2

Material - Fine AP; Peak No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-40-2	0.2010	298.7	4.43	-11.200
2-41-2	0.2034	330.9	8.80	-10.620
2-61-2	0.1989	310.1	2.00	-12.044
2-62-2	0.2006	318.6	9.80	-12.000

Table 6-3

Material - Fine AP; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-40-2	0.2010	443.0	4.37	-11.673
2-41-1	0.2019	430.2	2.13	-12.350
2-41-2	0.2034	479.0	8.40	-11.117
2-61-1	0.1989	420.6	2.10	-12.343
2-62-1	0.2006	459.8	11.00	-10.793
2-62-2	0.2003	443.8	4.20	-11.715

Table 6-4

Material - Medium AP; Peak No. 1

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-42-1	0.2002	241.4	2.23	-11.686
2-42-2	0.2004	245.8	4.21	-11.067
2-42-3	0.2015	258.7	11.70	-10.094
2-60-3	0.2024	253.3	4.00	-11.146
2-61-2	0.2047	252.10	2.20	-11.740
2-63-1	0.2005	250.5	10.00	-10.200

Table 6-5

Material - Medium AP; Peak No. 3

Sample No.	Sample Wt.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$

2-42-2	0.2004	293.0	4.11	-11.264
2-42-3	0.2015	318.0	8.72	-10.599
2-60-3	0.2024	310.1	4.10	-11.326
2-61-2	0.2047	315.2	2.00	-12.061
2-63-1	0.2005	313.0	9.40	-10.506

Table 6-6

Material - Medium AP; Peak No. 4

Sample No.	Sample Wt.	Peak T ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$

2-42-1	0.2002	434.4	2.13	-12.283
2-42-2	0.2004	441.1	3.95	-11.769
2-42-3	0.2015	456.8	10.48	-10.336
2-60-3	0.2024	458.6	4.10	-11.770
2-61-2	0.2047	439.3	2.30	-12.350
2-63-1	0.2005	446.3	8.70	-10.395

Table 6-7

Material - Coarse AP; Peak No. 1

Sample No.	Sample Wt.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$

2-44-1	0.2023	248.9	2.20	-11.727
2-45-1	0.2003	263.4	3.95	-11.200
2-45-2	0.2007	254.3	10.50	-10.135
2-59-3	0.2006	250.1	4.30	-11.050
2-60-1	0.2031	248.2	2.20	-11.725
2-60-2	0.2013	254.4	10.50	-10.135

Table 6-8

Material - Coarse AP; Peak No.2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$

2-45-2	0.2007	317.2	9.00	-10.564
2-45-1	0.2003	329.8	4.04	-11.408
2-59-3	0.2006	296.8	4.10	-11.270
2-60-1	0.2031	303.8	2.10	-11.950
2-60-2	0.2013	314.8	8.90	-10.300

Table 6-9

Material - Coarse AP; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$

2-44-1	0.2023	439.3	2.12	-12.385
2-45-2	0.2007	451.2	9.13	-10.969
2-45-1	0.2003	472.7	4.07	-11.811
2-59-3	0.2006	458.0	4.10	-11.778
2-60-1	0.2031	435.5	1.90	-11.466
2-60-2	0.2013	147.5	9.20	-10.641

Table 6-10

Summary of fine, medium and coarse AP DTA vs. nitrogen pressure and the computed activation energies.

Sample	Peak No.	Slope $\times 10^{-3}$	Act. Energy (kcal./mole)
Fine AP	1	-29.7	50.00
Fine AP	2	-12.8	25.42
Fine AP	4	- 9.2	19.67
Medium AP	1	-33.5	53.53
Medium AP	2	- 6.5	13.02
Medium AP	4	-12.0	20.47
Coarse AP	1	-33.0	52.72
Coarse AP	2	-15.5	24.31
Coarse AP	4	-35.3	55.76

7. The minimum size of sample holder that we have been able to construct and employ (pictured as Fig. 3 of Quarterly Report No. 2) required approximately 200 mg of sample of AP to adequately cover the thermocouple so that it could give sensible voltage values of ~~EMF~~ within the limits of amplification of our equipment.

It was felt that the heat liberated by such a large sample in the very short time of reaction was of such magnitude that it tended to make the sample subject to a temperature value not represented by or recorded as block temperature.

To overcome this difficulty it was decided to use a smaller AP sample but to provide the necessary volume of sample to cover the thermocouple adequately by adding an inert diluting material to the AP, namely very fine glass beads.

Unless otherwise noted the sample was made up by mixing 300 mg of glass beads with 100 mg of AP.

In order that the effect of the glass beads on the calculated results of activation energy might be noted, we made determinations on the medium size AP previously reported on in Quarterly Report No. 2 and on the No. 4 Huntsville Sample, both versus air and a nitrogen atmosphere at 60 mm of Hg in excess of air pressure, and these results are reported in the following tables. (Note - the measurements on the Huntsville No. 4 without glass beads are recorded in paragraph 6 of this report.)

Table 7-1

Material - Medium AP; Peak No. 1; vs. Air				
Sample No.	Sample Wt.	Peak T (°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-71-1	3/1	241.6	2.24	-11.6801
2-71-2	3/1	245.4	4.47	-11.0041
2-72-2	3/1	250.9	10.51	-10.1711

Table 7-2

Material - Medium AP; Peak No. 2; vs. Air				
Sample No.	Sample Wt.	Peak (°C)	Rate	$\ln(\text{Rate}/t_m^2)$
2-72-2	3/1	350.6	2.32	-10.8076
2-73-1	0.1995	321.8	2.66	-11.7838

Table 7-3

Material - Medium AP; Peak No. 4; vs. Air

Sample No.	Sample Wt.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$

2-71-1	3/1	409.4	2.00	-12.3585
2-71-2	3/1	440.0	4.25	-11.6924
2-72-2	3/1	462.3	10.00	-10.9024
2-73-1	0.1995	463.8	2.00	-12.4900

Table 7-4Material - H_4 ; Peak No. 1; vs. Air

Sample No.	Sample Wt.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$

2-64-1	3/1	256.8	2.34	-11.6954
2-64-2	3/1	258.8	4.25	-11.0992
2-67-1	3/1	251.7	10.40	-10.1844

Table 7-5Material - H_4 ; Peak No. 2; vs. Air

Sample No.	Sample Wt.	Peak T($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$

2-64-1	3/1	289.1	2.03	-11.9514
2-64-2	3/1	330.0	4.18	-11.3742
2-67-1	3/1	323.3	8.67	-10.5904

Table 7-6Material - H_4 ; Peak No. 4; vs. Air

Sample No.	Sample Wt.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$

2-64-1	3/1	433.6	2.13	-12.4351
2-64-2	3/1	467.5	4.32	-11.7518
2-67-1	3/1	470.9	8.47	-11.0873

Table 7-7Material - H₄; Peak No. 1; vs. Nitrogen

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-65-1	3/1	240.2	2.21	-11.8809
2-66-1	3/1	241.0	4.29	-11.9288
2-67-2	3/1	255.6	11.94	-10.0613

Table 7-8Material - H₄; Peak No. 2; vs. Nitrogen

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-65-1	3/1	262.5	1.94	-11.9777
2-66-1	3/1	303.3	3.97	-11.8350
2-67-2	3/1	324.9	6.73	-10.8203

Table 7-9Material - H₄; Peak No. 4; vs. Nitrogen

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-66-1	3/1	422.9	4.00	-11.7046
2-67-2	3/1	475.3	11.00	-10.3594

Table 7-10

Summary of activation energies calculated for two samples to note effect of using glass beads.

Sample	Atmosphere	Peak No.	Slope $\times 10^{-3}$	Act. Energy (kcal./mole)
Medium AP	Air	1	-45.8	95.0
Medium AP	Air	2	-16.45	50.7
Medium AP	Air	4	-15.00	29.8
H4	Air	1	-94.0	186.0
H4	Air	2	- 9.0	17.9
H4	Air	4	-21.6	42.9
H4	N2	1	-25.8	51.3
H4	N2	2	-11.0	21.9
H4	N2	4	- 9.5	18.9

8. In order to determine the influence of such things as particle size, shape of particle and added conditioners upon the activation energies associated with the decomposition of AP, we were furnished the following samples by Mr. Huskins of the AMO Propulsion Laboratory, Redstone Arsenal, Huntsville, Alabama.

These samples will be designated H-1 through H-6 and their specifications are as follows:

H-1: 400 micron, rounded AP, 99.2% minimum AP, conditioned with tricalcium phosphate (TCP), lot no. 4080.

H-2: 45 micron, rounded AP, 99.2% minimum AP, conditioned with TCP, lot no. 1030-194-1.

H-3: 17 micron, ground AP, conditioned with TCP, lot no. 2153.

H-4: 180 micron, unground AP, conditioned with TCP, lot no. 2153.

H-5: 8 micron, ground AP, conditioned with TCP.

H-6: 90 micron, rounded AP, conditioned with TCP, 99.2% minimum AP, lot no. 1075-33-11.

In the following tables are the peak temperatures measured for these samples at different heating rates. All of these samples were run versus air pressure, and without glass beads as a dilutant. A table summarizing the calculated activation energies of these samples concludes this paragraph.

Table 8-1

Material - AP H-1; Peak No. 1

Sample No.	Sample Wt.	Peak (°C)	Rate	$\ln(\text{Rate}/T_M^2)$

2-45-3	0.2004	248.6	4.48	-11.015
2-46-1	0.1997	254.9	10.39	-10.1973
2-54-1	0.2033	251.3	2.2	-11.720
2-72-1	0.1943	243.4	2.37	-11.620

Table 8-2

Material - AP, H-1; Peak No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_H^2)$
2-45-3	0.2004	290.7	1.11	-11.9586
2-46-1	0.1997	305.0	9.12	-10.8092
2-54-1	0.2033	284.9	2.1	-11.9070
2-72-1	0.1943	278.2	1.55	-11.9490

Table 8-3

Material - AP, H-1; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_H^2)$
2-54-1	0.2033	454.8	3.10	12.355
2-45-3	0.2004	445.0	4.50	-11.644
2-46-1	0.1997	440.6	10.36	-10.926

Table 8-4

Material - AP, H-2; Peak N 1

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_H^2)$
2-46-2	0.2013	241.9	4.37	-10.3912
2-46-2	0.2002	259.0	9.90	-10.2623
2-56-3	0.2029	245.0	2.20	-11.7120

Table 8-5

Material - AP, H-2; Peak No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_H^2)$
2-46-2	0.2013	237.3	4.16	-11.5811
2-46-2	0.2002	316.9	3.66	-10.8004
2-56-3	0.2029	279.3	9.77	-11.4977

Table 8-6

Material - AP, H-2; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-46-2	0.2013	427.4	3.87	-11.7535
2-48-2	0.2002	449.6	6.77	-10.9938
2-56-3	0.2029	429.4	2.10	-12.3673

Table 8-7

Material - AP, H-3; Peak No. 1

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-50-1	0.2002	248.6	4.3	-11.0560
2-50-2	0.2028	247.7	2.2	-11.7224
2-50-3	0.2002	255.7	10.4	-10.1996

Table 8-8

Material - AP, H-3; Peak No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-50-1	0.2002	299.5	4.3	-11.2600
2-50-2	0.2028	291.3	2.1	-11.9316
2-50-3	0.2002	325.7	9.2	-11.5708

Table C-9

Material - AP, H-3; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-50-1	0.2002	426.8	4.3	-11.8490
2-50-2	0.2028	424.4	2.0	-12.4019
2-50-3	0.2002	446.0	10.89	-10.7689

Table 8-10

Material - AP, H-4; Peak No. 1

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-49-2	0.2055	247.8	4.5	-11.0672
2-53-1	0.2010	244.2	2.5	-11.5812
2-56-1	0.2003	264.6	9.9	-10.2823

Table 8-11

Material - AP, H-4; Peak No.2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-49-2	0.2055	294.9	4.1	-11.2736
2-53-1	0.2010	268.8	2.1	-11.8485
2-56-1	0.2003	319.5	9.1	-10.5611

Table 8-12

Material - AP, H-4; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-49-2	0.2055	446.6	4.86	-11.6813
2-53-1	0.2010	439.5	2.10	-12.2954
2-56-1	0.2003	471.5	11.0	-10.3279

Table 8-13

Material - AP, H-5; Peak No. 1

Sample No.	Sample Wt.	Peak (°C)	Rate	$\ln(\text{Rate}/T_m^2)$
2-54-2	0.2003	251.3	4.5	-11.0663
2-58-1	0.2000	242.2	2.0	-11.7866
2-58-2	0.2003	260.7	9.7	-10.2801

Table 8-14

Material - AP, H-5; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-54-2	0.2003	427.5	4.1	-11.6752
2-58-1	0.2000	402.6	1.9	-12.5396
2-58-2	0.2003	453.1	10.2	-10.8540

Table 8-15

Material - AP, H-5; Peak No. 1

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-56-2	0.2000	553.0	4.4	-11.0107
2-58-3	0.2012	545.0	2.3	-11.7121
2-59-1	0.2004	557.6	10.7	-10.1723

Table 8-16

Material - AP, H-5; Peak No. 3

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-56-2	0.2000	532.6	4.2	-11.0147
2-58-3	0.2012	505.3	2.1	-12.3839
2-59-1	0.2004	545.3	9.0	-10.6375

Table 8-17

Material - AP, H-6; Peak No. 1

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-56-2	0.2000	483.5	4.2	-11.7500
2-58-3	0.2012	484.4	2.4	-12.2700
2-59-1	0.2004	485.4	8.6	-11.0347

Table 8-18

Summary of activation energies calculated for samples
supplied by Propulsion Laboratory.

Sample	Peak No.	Slope $\times 10^{-3}$	Act. Energy (kcal./mole)
H1	1	-29.7	59.0
H1	2	-16.6	83.0
H1	4	-68.0	123.5
H2	1	-20.2	40.1
H2	2	- 9.8	32.4
H2	4	-28.0	51.6
H3	1	-36.0	111.2
H3	2	-11.0	81.6
H3	4	-37.5	74.5
H4	1	-17.6	55.0
H4	2	- 7.2	14.5
H4	4	-25.6	43.9
H5	1	-22.8	45.3
H5	4	-15.4	30.6
H6	1	-35.0	69.5
H6	2	- 9.1	18.1
H6	4	-30.0	59.5

9. For the purpose of determining the influence of catalytic agents on the activation energies of the AP decomposition, DTA runs were made wherein a given amount of an added compound was mixed with the AP.

Two materials, finely powdered aluminum oxide and iron (III) oxide, have been studied for their catalytic effect on the AP decomposition reactions.

In all cases 0.10 g of AP was mixed with the glass beads in a 3:1 weight ratio and then 5% by weight of the AP equalled the weight of the added catalytic agent. All of these were physically stirred together for a length of time deemed sufficient to insure a uniform distribution of catalyst through out the mixture.

The following tables give the measured values for the DTA runs and the final table summarizes the computed activation energies of the reactions.

Table 9-1

Material - Fine AP, with Fe_2O_3 ; Peak No. 1; vs Air at atmospheric pressure

Sample No.	Peak T ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-85-1	247.0	2.1	-11.7664
2-85-2	248.9	14.9	- 9.8210
2-84-2	251.3	4.2	-11.0375

Table 9-2

Material - Fine AP, with Fe_2O_3 ; Peak No. 4; vs. air at atmospheric pressure.

Sample No.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-85-1	552.9	2.0	-12.1758
2-85-2	396.2	7.9	-10.9453
2-84-2	339.1	4.0	-11.5437

Table 9-3

Material - Fine AP, with Fe_2O_3 ; Peak No. 1; vs. O_2 at 60 mm. excess pressure.

Sample No.	Peak T($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-86-1	250.0	12.7	-10.4185
2-91-1	246.2	2.9	-11.7050
2-91-2	248.9	4.1	-11.3100

Table 9-4

Material - Fine AP, with Fe_2O_3 ; Peak No. 4; vs. N_2 at 60 mm. excess pressure

Sample No.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-86-1	397.4	8.0	-10.9306
2-91-1	357.8	2.0	-12.1700
2-91-2	380.0	3.8	-11.3500

Table 9-5Material - Medium AP, with Fe_2O_3 ; Peak No. 1; vs. Air

Sample No.	Peak T($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-79-1	250.1	13.7	- 9.9042
2-82-3	252.9	4.3	-11.063
2-82-2	250.9	2.2	-11.7167
2-81-1	250.1	2.2	-11.7137

Table 9-6Material - Medium AP, with Fe_2O_3 ; Peak No. 4; vs. Air

Sample No.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-79-1	401.9	9.13	-10.9181
2-82-3	400.0	4.13	-11.6037
2-82-2	372.9	2.13	-12.1257
2-81-1	372.5	2.13	-12.1243

Table 9-7Material - Medium AP, with Fe_2O_3 ; Peak No. 1; vs. N_2 at
60 mm. excess pressure.

Sample No.	Peak T($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-81-1	252.5	13.50	- 9.9236
2-83-2	251.7	4.31	-11.0655
2-83-1	251.3	2.11	-11.7780

Table 9-8

Material - Medium AP, with Fe_2O_3 ; Peak No. 4; vs. N_2 at
60 mm. excess pressure.

Sample No.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-81-1	419.1	8.38	-10.9540
2-83-2	395.1	4.13	-11.5911
2-83-1	373.6	2.13	-12.1876

Table 9-9

Material - Fine AP, with Al_2O_3 ; Peak No. 1; vs. Air

Sample No.	Peak T ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-79-2	249.7	4.34	-11.0509
2-80-2	252.1	13.80	-9.9032
2-81-2	252.5	2.47	-11.6250

Table 9-10

Material - Fine AP, with Al_2O_3 ; Peak No. 4; vs. Air

Sample No.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-79-2	596.3	4.00	-11.3236
2-80-2	418.0	8.00	-10.9973
2-81-2	377.3	2.25	-12.1160

Table 9-11

Material - Fine AP, with Al_2O_3 ; Peak No. 1; vs. N_2 at
60 mm. excess pressure.

Sample No.	Peak T ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_m^2)$
2-78-2	255.6	4.16	-11.1154
2-78-3	251.3	11.45	-10.0869
2-80-1	253.0	2.37	-11.6703

Table 9-12

Material - Fine AP, with Al_2O_3 ; Peak No. 4; vs. N_2 at
60 mm. excess pressure.

Sample No.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_M^2)$
2-78-2	388.7	4.13	-11.5718
2-78-3	419.1	9.75	-10.8038
2-80-1	375.9	2.00	-12.2547

Table 9-13

Material - Medium AP, with Al_2O_3 ; Peak No. 1; vs. Air

Sample No.	Peak T($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_M^2)$
2-76-1	247.8	4.54	-11.8434
2-76-2	251.7	12.70	- 9.9813
2-77-2	248.5	1.97	-11.838

Table 9-14

Material - Medium AP, with Al_2O_3 ; Peak No. 4; vs. Air

Sample No.	Peak ($^{\circ}\text{C}$)	Rate	$\ln(\text{Rate}/T_M^2)$
2-76-1	404.9	3.88	-11.8826
2-76-2	433.6	10.38	-10.7814
2-77-2	386.1	2.25	-12.1713

Table 9-15

Material - Medium AP, with Al_2O_3 ; Peak No. 1; vs. N_2 at
60 mm. excess pressure.

Sample No.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-76-3	252.1	4.34	-11.0593
2-77-1	252.5	13.03	- 9.9621
2-78-1	252.1	2.03	-11.7954

Table 9-16

Material - Medium AP, with Al_2O_3 ; Peak No. 2; vs. N_2 at
60 mm. excess pressure.

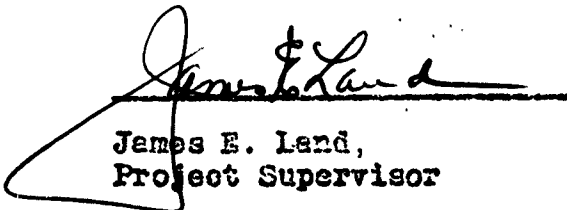
Sample No.	Peak (°C)	Rate	$\ln(\text{Rate}/T_M^2)$
2-76-3	327.0	4.00	-11.6293
2-77-1	435.9	2.00	-11.0484
2-78-1	371.4	2.13	-12.1316

Table 9-17

Summary of activation energies calculated for AP with
added catalysts.

Sample	Atmosphere	Peak	Slope $\times 10^{-3}$	Act. Energy (kcal./mole)
Fine AP/ Fe_2O_3	Air	1	-90.0	178.3
"	Air	4	-11.2	22.35
"	N_2	1	- 260	517.0
"	N_2	4	-15.1	30.0
Medium AP/ Fe_2O_3	Air	1	- 7.7	15.3
"	Air	4	-13.8	27.5
"	N_2	1	- 421	856.0
"	N_2	4	-12.2	24.0
Fine AP/ Al_2O_3	Air	1	-134.5	267.0
"	Air	4	-12.9	25.7
"	N_2	1	- 92	182.3
"	N_2	4	-14.8	29.5
Medium AP/ Al_2O_3	Air	1	-12.5	24.8
"	Air	4	-13.6	26.9
"	N_2	1	-83.9	166.7
"	N_2	4	- 9.0	17.9

10. It must be emphasized that the data quoted in these Quarterly Reports represent all runs made and is not to be considered the final answer in each case. Such data will be subject to further rechecking and consideration. In some cases it may be necessary, in light of new measurements, to alter, discard or modify some of these recorded values.



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