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INFORMAL REPORT

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PLAINTIFF'S EXHIBIT
UC-137

IMPROVING THE OPTICAL PROPERTIES OF PAPER WITH ASBESTOS T-135

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SUMMARY

A series of Asbestos T-135 treated products were evaluated in laboratory handsheets to determine their efficiency as opacifiers. Highly sheared and chemically dispersed fillers showed marked improvements over standard Hermann Disintegrator opened filler. Oven-dried mixtures of High Purity Asbestos and titania did not significantly improve the opacifying properties of the product over 200°C. Heating the Asbestos T-135 slurry from 11°C to 70°C didn't show any improvement in opacity of the sheet. Deionized water used in preparation of handsheets resulted in higher properties than with tap water.

EXPERIMENTAL

The objective of the study was to determine whether or not various physical treatments of the Asbestos-titania co-flocculated products would alter the opacifying properties of the handsheets. Each filler was added to the pulp slurry at three levels, 10, 15, and 20%. A control sample, containing no filler, was run with each series of tests. The handsheets were tested for their light scattering properties and relative filler retention (see sample calculations at end of report).

ASBESTOS-TITANIA SLURRY PREPARATION

All the fillers used in the handsheets, excluding those dried in the laboratory, were King City Asbestos T-135 slurried pellets. Five series of handsheets were prepared to evaluate the various treatments of the fillers:

1. Asbestos-titania co-flocculated mix (2:1) dried at 100°, 200°, 400°, and 600°C. These fillers were then slurried and handsheets prepared under normal conditions (Table I).

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Chemicals and Plastics
Union Carbide Corporation
Niagara Falls, New York

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2. Asbestos T-135 pellets slurried in the Hermann Disintegrator at 11°, 35°, and 70°C and then used in preparation of handsheets. (Table II)

3. Asbestos T-135 pellets slurried in the Hermann Disintegrator compared with pellets opened under high shear in the Waring Blendor. (Table III)

4. One per cent acetic acid-treated Asbestos T-135 compared with Hermann Disintegrator slurried pellets. (Table IV)

5. Deionized water compared with tap water effect on slurried pellets. (Table V)

TEST RESULTS

A tabulated listing of the light scattering and retention data obtained from the evaluated handsheets is reported in Tables I through V. A summary of the average light scattering properties and retention of filler is listed below:

Average Optical and Retention Properties of Asbestos-Titania Fillers

Sample	s (Light Scattering of Sheet)	s_p (Scattering Power of Filler)	% Retention
Heat treated Asb.-titania 100°C	550	2618	8.63
200°C	590	3010	8.97
400°C	549	2610	8.57
600°C	561	2786	8.62
Slurry Temp. of Asbestos T-135*11°C	598	3400	8.07
35°C	604	3250	8.67
70°C	617	3362	8.77
Herman Disintegrator Asbestos T-135	633	3378	9.11
Waring Blendor T-135	674	3821	9.50
Acetic Acid-treated T-135	710	4108	9.48
Deionized Water T-135	632	3624	8.70
Tap Water T-135	604	3250	8.67

*Tap Water

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CONCLUSIONS

Based on the results obtained from the laboratory prepared handsheets, the following can be concluded.

1. Elevated drying of asbestos-titania did not show any significant change in the opacifying properties of the filler. The T-135 King City product appears to be more effective than any product produced in the laboratory.

2. Slurrying and processing handsheets at elevated temperature showed no beneficial effects.

3. Applying high shear to the filler (Waring Blendor) improves both optical and retention properties of the product.

4. Chemically dispersed T-135 with 1% acetic acid showed marked improvements in the optical properties of the sheet.

5. Processing sheets and filler with deionized water proved to be more beneficial than using tap water.

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F. H. Thompson

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TABLE I

Effect of Drying Co-flocculated High Purity Asbestos and TiO_2*

Filler Addition	Control	100°C Filler			200°C Filler			400°C Filler			600°C Filler		
		10%	15%	20%	10%	15%	20%	10%	15%	20%	10%	15%	20%
Basis Wt.	9151	9231	9225	9150	9189	9371	9365	8971	9217	9235	9123	9488	9063
R_o	.728	.767	.793	.807	.774	.801	.814	.760	.786	.808	.770	.791	.805
R_w	.844	.842	.850	.850	.843	.847	.849	.838	.841	.848	.840	.841	.846
$C_{0.89}$	.863	.911	.933	.949	.918	.946	.959	.907	.935	.953	.917	.941	.952
$\underline{s}_w$	3.185	4.221	5.083	5.871	4.450	5.613	6.434	4.064	5.006	6.027	4.365	5.259	5.910
R_∞	.822	.828	.840	.843	.830	.839	.843	.822	.830	.841	.826	.831	.839
$\underline{s}$	348	457	551	642	484	599	687	453	543	653	478	554	652
% Ash	0.45	5.72	8.44	11.46	5.73	9.18	12.04	5.61	8.64	11.32	5.62	8.18	11.35
% Asb.	None	4.12	5.88	8.08	3.84	6.16	8.56	4.00	6.24	7.72	4.12	5.80	8.00
% TiO_2	None	1.56	2.62	3.65	1.56	2.91	3.81	1.55	2.57	3.64	1.66	2.60	3.68
% T	0	5.68	8.50	11.73	5.49	9.07	12.37	5.55	8.81	11.36	5.78	8.40	11.68
$\underline{s}_p$	0	2270	2735	2850	2829	3114	3088	2239	2562	3029	2604	2803	2951

*Sample calculations at end of report.

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TABLE II

Effect of Slurry Temperature Asbestos T-135

Filler	Control	11°C			35°C			70°C		
		10%	15%	20%	10%	15%	20%	10%	15%	20%
Basis Wt.	9292	9208	9357	9087	9434	9409	9010	9234	9087	8950
R_o	.722	.722	.800	.809	.771	.795	.811	.770	.795	.809
R_w	.829	.841	.842	.843	.831	.837	.842	.830	.836	.840
$C_{0.89}$	.871	.918	.950	.960	.928	.950	.963	.928	.951	.963
R_∞	.804	.828	.834	.837	.818	.828	.836	.817	.828	.834
S_w	3.211	4.417	5.749	6.358	4.565	5.637	6.588	4.588	5.678	6.533
S	346	480	614	700	484	599	731	497	625	730
% Ash	0.70	5.72	8.63	11.08	6.04	8.96	12.20	6.41	9.65	11.85
% Asb.	0	3.64	5.84	7.72	3.92	5.92	8.36	4.08	6.20	7.76
% TiO_2	0	1.38	2.42	3.21	1.52	2.61	3.69	1.64	2.91	3.74
% T-135	0	5.02	8.26	10.93	5.44	8.53	12.05	5.72	9.11	11.50
S_p	0	3017	3600	3585	2888	3317	3545	2990	3411	3687

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TABLE III

Effect of Mechanical Opening on Asbestos T-135

Waring Blendor vs. Hermann Disintegrator

Filler	Control	Waring Blendor			Hermann Disintegrator		
		10%	15%	20%	10%	15%	20%
Basis Wt.	9286	9462	9454	9055	9426	9034	9366
R_o	.727	.794	.814	.827	.781	.810	.824
R_w	.842	.844	.850	.857	.843	.850	.853
$C_{0.89}$	.863	.941	.958	.965	.926	.953	.966
R_∞	.819	.835	.844	.853	.831	.843	.849
S_w	3.184	5.319	6.379	7.126	4.422	6.076	7.102
S	343	562	675	787	469	673	758
% Ash	0.55	6.77	9.65	12.72	5.78	9.63	12.47
% Asb.		4.48	6.20	8.56	4.12	6.36	8.28
% TiO_2		2.03	3.10	4.13	1.56	3.09	3.94
% T-135		6.51	9.30	12.69	5.68	9.45	12.22
S_p		3710	3911	3842	2562	3831	3742

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TABLE IV

Effect of Hermann Disintegrator on Asbestos T-135

1% Acetic Acid Treatment

Filler Addition	Control	Hermann			Acetic Acid		
		10%	15%	20%	10%	15%	20%
Basis Wt.	8937	9426	9035	9366	9228	8995	8849
R_o	.728	.781	.810	.824	.798	.820	.827
R_w	.847	.843	.850	.853	.850	.854	.856
$C_{0.89}$	.860	.926	.953	.966	.939	.980	.966
R_∞	.845	.831	.843	.849	.857	.862	.865
S_w	3.156	4.422	6.076	7.102	5.336	6.656	7.196
S	353	469	673	758	578	740	813
% Ash	0.57	5.78	9.63	12.47	6.37	9.67	12.53
% Asb.		4.12	6.36	8.28	4.12	6.12	8.16
% TiO_2		1.56	3.09	3.94	2.21	3.36	4.49
% T-135		5.68	9.45	12.22	6.33	9.48	12.65
S_p		2562	3831	3742	3902	4430	3992

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TABLE V

Effect of Deionized Water vs. Tap Water on Asbestos T-135

Filler Addition	Deionized Water			Tap Water		
	10%	15%	20%	10%	15%	20%
Basis Wt.	9288	9214	9178	9434	9409	9010
R_o	.786	.805	.822	.771	.795	.811
R_w	.846	.847	.855	.831	.837	.842
$C_{0.89}$	.929	.950	.961	.928	.950	.963
R_∞	.835	.840	.850	.818	.828	.836
S_w	4.868	5.867	6.775	4.565	5.637	6.588
S	524	637	736	484	599	731
% Ash	6.13	8.87	11.58	6.04	8.96	12.20
% Asb.	4.16	5.84	8.20	3.92	5.92	8.36
% TiO_2	1.59	2.67	3.66	1.52	2.61	3.69
% T-135	5.75	8.51	11.86	5.44	8.53	12.05
S_p	3450	3767	3655	2888	3317	3545

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SAMPLE CALCULATIONS

Nomenclature

R_w = % reflectance of sheet backed by white body (0.89% absolute reflectance)

R_o = % reflectance of sheet backed by black body (cavity)

R_∞ = % reflectance of infinitely thick sheet of paper

$C_{.89} = R_o/R_w$ - TAPPI opacity

$\underline{k}\ \underline{k}_f\ k_p$ = Absorption coefficient ($cm^2/g.$) of sheet, fiber, pigment

$\underline{s}\ \underline{s}_f\ \underline{s}_p$ = Scattering coefficient ($cm^2/g.$) of sheet, fiber, pigment

$\underline{k}W$ = Absorbing power - pure number

$\underline{s}W$ - Scattering power - pure number

$\underline{W}\ \underline{W}_f\ \underline{W}_p$ = Basis weight of sheet, fiber component, and pigment ($g./cm^2$)

y = % pigment in sheet

The calculations for the scattering and absorption coefficients were based on the experimental data; basis weight ($g./cm^2$). R_o and R_w (Bausch & Lomb opacimeter), and the chemical determinations for pigment content in the paper.

Scattering $\underline{s}$ and absorption $\underline{k}$ coefficients for the basic cellulose fiber were obtained from blank sets (no filler-2% alum only) employing the Kubelka-Munk equations as follows:

(1) $C_{.89}$ = TAPPI opacity = R_o/R_w
sW was obtained from the Kubelka-Munk curves TAPPI Standards (T425M-60) using R_o and the calculated $C_{.89}$ (R_o/R_w)

(2) For reasons of accuracy R_∞ was calculated rather than obtained from the Kubelka-Munk curves

$$R_\infty = a - (a^2-1)^{1/2}$$

where: $\underline{a} = (R_w/2) + (R_o - R_w + 0.89)/(1.78\ R_o)$

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(3) Scattering coefficient of the sheet was calculated as:

$\underline{s} = \underline{sW}/\underline{W}$ $\quad\quad$ $\underline{W}$ = basis weight g./cm^2

Where the paper is 100% cellulose, $\underline{s}_f$ of the fiber is equal to the $\underline{s}$ of the sheet.

(4) The absorption coefficient of the paper was determined by $\underline{k} = \underline{s}\ (\underline{k}/\underline{s})$ where $\underline{k}/\underline{s} = (1-R)^2/2R$

(5) Scattering coefficients of the fillers were individually calculated.

$$\underline{s}_p = \frac{\underline{s} - (1-y)\underline{s}_f}{y}$$ where y = % filler in sheet

(6) Similarly, the absorption coefficients of the fillers were obtained by:

$$\underline{k}_p = \frac{\underline{k} - (1-y)\underline{k}_f}{y}$$

At the lower levels of filler (5-10%), light scattering and filler content approximate a linear relationship. This was verified by plotting $\underline{s}$ of the sheet versus % filler in paper. Therefore, the scattering and absorption coefficients for each filler were also calculated using the least square method for determining a slope of a straight line. This procedure was considered the most accurate for determining $\underline{s}$ and $\underline{k}$ for the fillers; however, both values were reported.

(7) The scattering coefficient for TiO_2 in the presence of asbestos was obtained by using the calculated $\underline{s}$ values for the fiber and asbestos.

$$\underline{s}_{TiO_2} = \frac{\underline{s}\ \text{sheet} - (1-y-x)\underline{s}_f - x\underline{s}\ \text{asbestos}}{y}$$

where y = % TiO_2 in sheet
x = % asbestos in sheet

(8) Pigment Efficiency was determined as:

P.E. = $\underline{sW}$/% filler retained

(9) Per cent filler Retention was calculated by the standard procedure defined as:

$$\% \text{ Retention} = \frac{\% \text{ Filler in paper}}{\% \text{ Filler Added}} \times 100$$

Asbestos ($Mg_6(OH)_8Si_4O_{10}$) was analyzed by % Mg where % Mg x 4.0 = % asbestos retained. TiO_2 was determined by direct analysis.

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