

JRD

Preliminary Technical Bulletin

Opalon R-7611

0623890

JRD SPILL

Preliminary Technical Bulletin

Opalon R-7611

by: Robert N. Garlick
April 15, 1969

MONSANTO COMPANY
HYDROCARBONS AND POLYMERS DIVISION
RESEARCH DEPARTMENT
SPRINGFIELD, MASSACHUSETTS

0623891

TOWOLDMON0039596

WATER_PCB-00024065

INTRODUCTION

Opalon R-7611 is a stir-in foamable paste resin developed to meet the needs of the molding, flooring, and coating industries. The superior rheological properties along with excellent physical properties and foam quality make this resin ideal for applications such as;

1. Coated Fabric
 - a. outer wear
 - b. hand bags
 - c. upholstery
2. Flooring Foam Layer
3. Slush Molded Footwear
4. Foam Sheet
5. Carpet backing pad

Typical Resin Properties

Polymer	PVC homopolymer
Specific Viscosity	0.42*
Maximum Heat Loss	0.3%
Appearance	White Powder
Bulk Density	15 lbs./ft. ³
Average Particle Size	2.0-3.0 u

*0.40 grams resin in 100 ml. cyclohexane - measured at 25°C

0623891.01

RHEOLOGICAL PROPERTIES

Viscosity

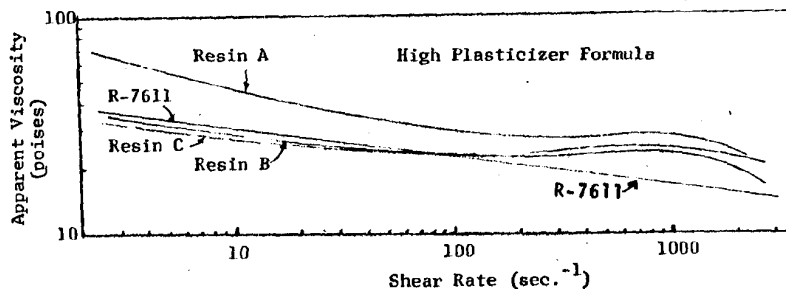
The rheological properties of Opalon R-7611 are superior to all competitive resins tested. Figure I shows the viscosity of several resins in a high plasticizer formulation. Figure 11 is a similar plot for the same resins in a low plasticizer system.

Resin	Low Plasticizer Formulation	High Plasticizer Formulation
Resin	100	100
Diocetyl phthalate (DOP)	25	45
Santicizer 160	25	45
Paraplex G-62	5	.5
Dyphos* (National Lead)	4	4
Azodicarbonamide*	4	4

*paste (50/50 powder in DOP)

FIGURE I

Apparent Viscosity of Plastisols

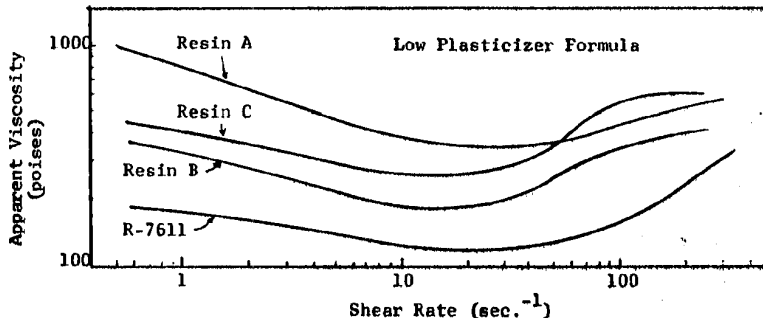


0623892

In the high plasticizer system, R-7611 is competitive in the lower shear rate range and superior in the higher shear rate range. Opalon R-7611 also shows no dilatancy.

FIGURE II

Apparent Viscosity of Plastisols



In the low plasticizer system, R-7611 has the lowest viscosity at all shear rate ranges, and is better by a factor of two. The superior flow properties of R-7611 will allow faster coating speeds and a smoother surface. Processes requiring high shear pumping will experience a lower heat build-up.

Viscosity Aging

The following table shows the viscosity aging in 60 phr DOP formulation. The magnitude of the viscosity is again substantially less than the competitive foam resins tested, and the percentage increase after 7 days is the least with Opalon R-7611.

0623893

TABLE I

Viscosity Aging (25°C)

HAT Brookfield Viscometer, 20 rpm, centipoises

	<u>R-7611</u>	<u>Resin A</u>	<u>Resin B</u>	<u>Resin C</u>
2 hr.	8800	13300	10900	22300
24 hr.	11600	19000	17200	29000
7 day	17800	29000	24800	48000
Percent Increase (7 day vs. 24 hr.)	102%	123%	128%	115%

Good viscosity aging is of prime importance for the compounder who frequently encounters high temperatures in storage, warehousing or trucking. Batch ends may be stored for longer periods of time resulting in substantial savings for the processor.

Filled Formulations

Since fillers are widely used in foam applications, the flow behavior of atomite filled systems was investigated. A CaCO_3 loaded system with Opalon R-7611 again had an unusually low viscosity and proved itself superior to competitive foam resins.

Resin	100
DOP	100
Atomite	50
Stabilizer	2

0623894

TOWOLDMON0039600

WATER_PCB-00024069

TABLE II
Viscosity of Filled Plastisol (cps)

	<u>R-7611</u>	<u>Resin A</u>
Brookfield; 5 rpm	10740	29120
50 rpm	3776	8000
Severs; 90 psig	2998	4012

High filler loading and subsequent reduction in formulation costs can be attained with Opalon R-7611 without adversely affecting rheology. Fillers can, however, have a detrimental effect on foam quality so that no more than 25 phr are recommended where optimum physical properties are desired.

Pigmented System

The effect of TiO_2 was also checked in the following formulation. Opalon R-7611 again had a superior viscosity by a factor of two. A minimum viscosity will aid in eliminating entrapped air and flow marks caused by the coating blade or roll.

Resin	100
DOP	25
Santicizer 160	25
Dyphos*	4
Azodicarbonamide*	4
TiO_2 (rutile)	5

*paste (50/50 powder in DOP)

0623895

TABLE III

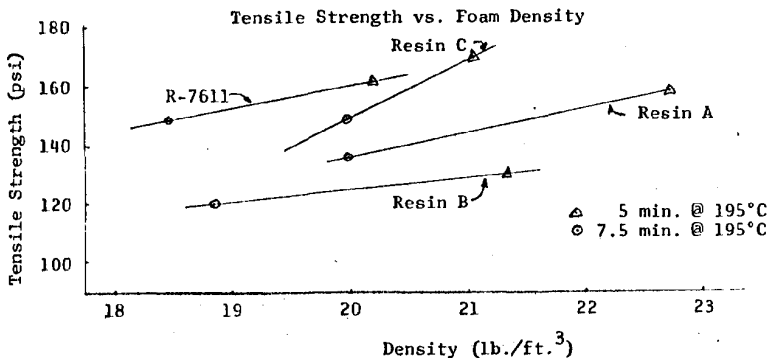
Viscosity of Pigmented System (cps)

	<u>R-7611</u>	<u>Resin A</u>	<u>Resin B</u>
Brookfield; 5 rpm	22400	128000	41200
20 rpm	16960	68800	28500
50 rpm	14912	50240	25600
Severs; 50 psig	41300	59800	70700

It should be noted from the studies on rheology that Opalon R-7611 has a substantially lower viscosity than the competitive foam resins tested and is superior in overall rheological properties. These advantages can be utilized by any application in which flow is important.

PHYSICAL PROPERTIES

Using the high plasticizer formulation (page 2) thin films (24 mls) were made at 195°C at various times. The tensile strength of the samples was determined, and is plotted in Figure III versus the foam density.

FIGURE III

0623896

When compared at an equal density, Opalon R-7611 has a higher tensile strength. This plot also demonstrates that Opalon R-7611 has a lower ultimate density for a given time of exposure at 195°C.

Other physical properties included in the evaluation were compression set (the set after being compressed to one half its original thickness for 22 hrs. at 22°C), compression resistance (the load necessary to compress the thickness 50%), percent elongation and 100% elongation.

The data is shown in Table IV, including the density at which the properties were evaluated. The properties of Opalon R-7611 would have improved if evaluated at a density equivalent to the competitive resins. In all cases Opalon R-7611 was shown to be competitive or better than the commercial foam resins tested.

Table IV

Average Physical Properties

	<u>R-7611</u>	<u>Resin A</u>	<u>Resin B</u>	<u>Resin C</u>
Compression Set	15 psi	15 psi	25 psi	14 psi
Compression Resistance	29 psi	30 psi	31 psi	31 psi
Percent Elongation	160%	155%	156%	120%
100% Modulus	169 psi	152 psi	154 psi	144 psi
Density	14.9 lb/ft ³	16.4 lb/ft ³	16.6 lb/ft ³	16.9 lb/ft ³

HEAT STABILITY

The basic heat stability of Opalon R-7611 was compared to commercial foam resins. Stabilizers normally used in foam formulations such as Synpron 936 (Synthetic Products Co.), Advastab ABC-2 (Advance), Mark 552 (Argus Chemical Co.), and Dyphos (National Lead) were tested in the following non-foam formulation.

Resin	100
DOP	60
G-62	5
Stabilizer	2

0623897

TABLE V

Heat Stability of Opalon R-7611

<u>Time @ 195°C</u>	<u>R-7611</u>	<u>Resin A</u>	<u>Resin B</u>	<u>Resin C</u>
Synpron 936				
5 min.	clear	clear	clear	clear
10	light yellow	clear	clear	light yellow
15	yellow	yellow	yellow	yellow
25	yellow	orange	orange	orange
Advastab ABC-2				
5 min.	clear	clear	clear	clear
10	light yellow	light yellow	light yellow	light yellow
15	black	black	yellow	black
25	black	black	black	black
Mark 552				
5 min.	clear	clear	clear	clear
10	clear	clear	clear	clear
15	black	black	black	black
Dyphos				
5 min.	white	white	white	white
10	light tan	tan	light tan	light tan
15	tan	brown	tan	brown

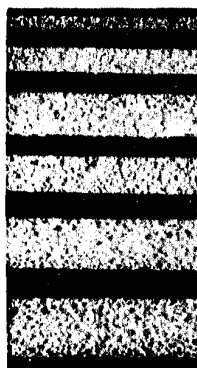
0623898

FOAM QUALITY

Foam samples of the four resins in both high and low plasticizer formulations were made by heating at 195°C. Various oven times were used. The cell structure of Opalon R-7611 is superior to the other resins at 8 and 10 min. in the high plasticizer formulation. Figure IV shows samples of Opalon R-7611 and a widely used foam resin. When exposed for times longer than 10 min., all the resins began to degrade.

FIGURE IV

Time @ 195°C



R-7611

3 min.

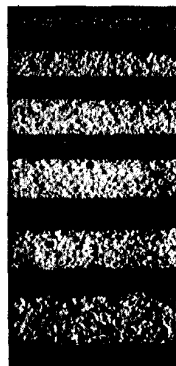
4

5

6

8

10



Foam Resin

The use of Opalon R-7611 will consistently result in a foam having fine, uniform cells and good color.

0623899

STABILIZER SELECTION

The excellent foam quality (i.e., cell structure, surface and color) of Opalon R-7611 shown in Figure IV is the result of a properly balanced formulation. The foam quality of expanded vinyls is actually determined during the heating cycle when the plastisol is in the "melt region". The selection of a stabilizer which causes decomposition of the blowing agent at the optimum temperature is the critical factor in obtaining good foam quality.

The variation of melt viscosity with temperature for a plastisol will be fixed for a given formulation, whereas the decomposition rate and decomposition temperature of the blowing agent will vary with the type and level of stabilizer selected. This is the most important variable available for improving foam quality. The properties of some stabilizers which give good foam quality with Opalon R-7611 are shown in Table VI. The active ingredients of each stabilizer are shown in Table VII.

Each stabilizer produces optimum foam quality under a fairly narrow set of conditions as specified by the melt viscosity of the plastisol. Both decomposition temperature and decomposition rate of the blowing agent-stabilizer system must be considered. In general, a plastisol with a higher fusion temperature requires a stabilizer which activates decomposition at a higher temperature. A high melt viscosity requires the use of a stabilizer producing a slow decomposition rate. The best combination of stabilizer properties for use with Opalon R-7611 is an intermediate decomposition temperature and a moderate decomposition rate. For most plastisols based on Opalon R-7611, Advastab ABC-1 and ABC-2, Ferro 5373 and Ferro 5473, and Nuostable V-1026 are recommended. The actual stabilizer used will depend on the melt viscosity of the complete formulation.

0623900

There are some other factors to consider in selecting a stabilizer.

1. Lead stabilizers can have a detrimental effect on the foam color by increasing susceptibility to "sulfur staining". Zinc stabilizers work equally well and do not cause this problem.
2. The stabilizer must be well dispersed to obtain the best results. Liquid stabilizers are easier to disperse, as well as handle, and may eliminate a potential problem.
3. The processing conditions such as dwell time, oven temperature, and oven air velocity all affect the heating rate of the plastisol. It is suggested that several stabilizers be run through the processing line to determine the optimum one for the formulation.

0623901

TABLE VI

<u>Stabilizer</u>	Foam <u>Density</u>	Blow-Up	<u>Color</u> (1)	Decomposition	
		<u>Ratio</u>		<u>Temp.</u>	<u>Rate</u>
Advastab ABC-1	16.3 lb/ft ³	4.4	7.8	180°C	Moderate
Advastab ABC-2	17.7	4.1	5.7	170	Moderate
Dyphos	18.7	3.8	5.5	164	Fast
Ferro 5373	15.8	4.6	9.4	170	Slow
Ferro 5473	16.5	4.4	1.0	177	Moderate
Nuostab V-1026	15.9	4.6	5.6	182	Moderate
Mark 552	17.5	4.1	0.0	177	Fast-Moderate

(1) Color eye correlation $\frac{X^* - Z^*}{Y^*} \times 100$ (The higher the figure, the whiter the foam color)

$X^* = 0.685 X$

$Y^* = 0.875 Y$

$Z^* = 1.023 Z$

Formulation

Opalon R-7611	100
DOP	60
Kempore 125	2
Stabilizer	2

TABLE VII

<u>Stabilizer</u>	<u>Active Ingredients</u>
Advastab ABC-1 (Advance Div., Carlisle Chem. Co.)	Modified Liq. Zn
Advastab ABC-2 (Advance Div., Carlisle Chem. Co.)	" " "
Dyphos (National Lead Company)	Dibasic lead phosphite
Ferro 5373 (Ferro Corporation)	Liq. Pb-Zn, organic inhibitor
Ferro 5473 (Ferro Corporation)	Liq. Zn, " "
Nuostab V-1026 (Nuodex Division)	Liq. Pb complex
Mark 552 (Argus Chemical Corporation)	Modified Liq. Cd-Zn

0623902

Recommended Formulations

The following formulations are suggested starting points for typical uses of vinyl foam resin.

Coated Fabric

Upholstery

Opalon R-7611	100
DOP	45
Santicizer 160	35
Paraplex G-62	5
Ferro 5375	2
Atomite	40
Kempore 125	2

Outerwear

Opalon R-7611	100
DOP	45
Santicizer 160	45
DOA	10
Paraplex G-62	5
Advastab ABC-2	3
TiO ₂	5
Kempore 125	3

Flooring

Opalon R-7611	100
DOP	25
Santicizer 160	25
Paraplex G-62	5
Mark 552	2
TiO ₂	5
Kempore 125	3

Carpets Backing

Opalon R-7611	100
DOP	62
Santicizer 160	29
Paraplex G-62	5
Advastab ABC-2	2
Kempore 125	3

0623903