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APPENDICE

APPENDIX A

Tests for Unsaturated polyester

A1. Acid Value (ASTM D 1639-90)

This method is used to determine the free acidity present in the non-volatile portion of resins. The specimen (2-3 g) is dissolved in a mixture of toluene and methanol (0:30 v/v), then is titrated with 0.1 KOH using phenolpthalein as an indicator. The acid value is calculated as follows;

$$\text{Acid Value (mg KOH/g)} = \frac{VK}{SxN}$$

Where:

V = volume of KOH solution required for titration of the specimen, ml

K = weight of KOH per millilitre of KOH solution, mg

S = specimen weight, g

N = non-volatile content of the material expressed as a decimal fraction.

A2. Non-volatile Content (ASTM D 1644)

The method determines the fraction of resin that is relatively satiable at temperature of the test (105°C, 3 h) while volatile solvents are driven off. The non-volatile content is calculated as follows;

Non-volatile content, % = {(C-A)/S} x 100

Where:

A = weight of aluminium dish, g

S = weight of specimen used, g

C = weight of aluminium dish and content after heating, g

A3. SPI Gel Test

The specimen is measured by curing at 60°C and plotting the exothermal temperature against time by the temperature recorder. The time is required for the mixture from 65°C to reach 90°C is defined as the geltime, the time is required for the mixture to reach the maximum temperature from 65°C is defined as the cureltime, and the temperature for which the specimen to reach the maximum temperature is defined as the maximum exothermic temperature. The example graph is shown in Figure A-1.

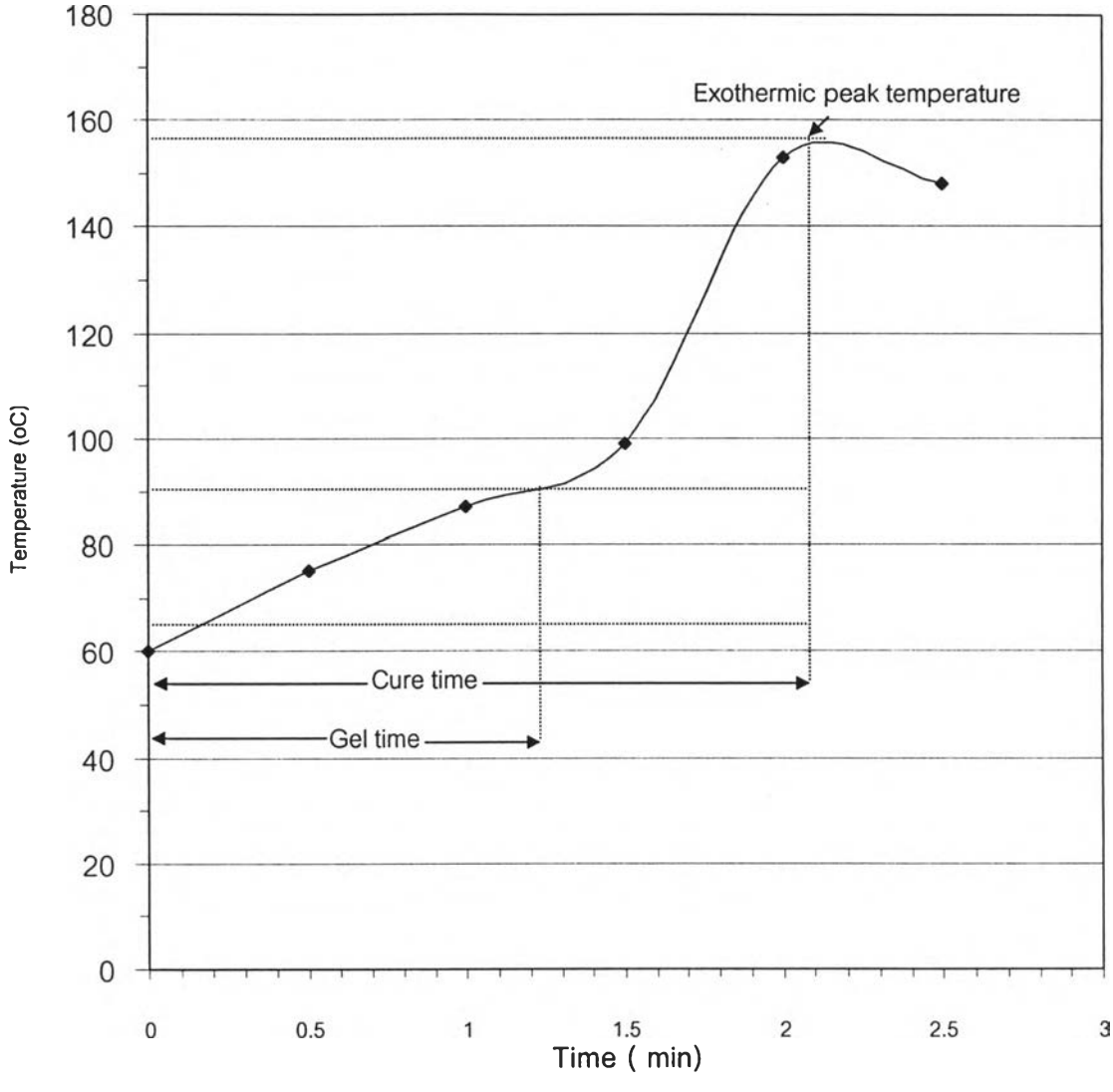


Figure A-1 The exothermal temperature graph by SPI gel test

APPENDIX B

Mechanical Properties Tests for Unsaturated polyester

B1. Tensile Strength (ASTM D638-93)

Tensile strength is a measure of the resistance of a material to stress pulling in opposition direction.

$$\text{Tensile strength } (N/mm^2) = \frac{\text{Load (N)}}{\text{Cross-sectional area } (mm^2)}$$

Load is the maximum load to cause failure of the specimen. Cross-section area is the multiply the width by the thickness of the neck area.

B2. Flexural Strength (ASTM D790)

Flexural strength is the maximum flexural stress that obtained by a method wherein the product of the flexural load applied to a test piece at a speed test and the distance between supporting points is divided by the width of the piece and the squre of the height of the test piece and is multiplied by a factor.

In this study the specimen size of 60x25x3 mm and the span is 48 mm. The tested specimen is placed on a supporting as shown in Figure B-1

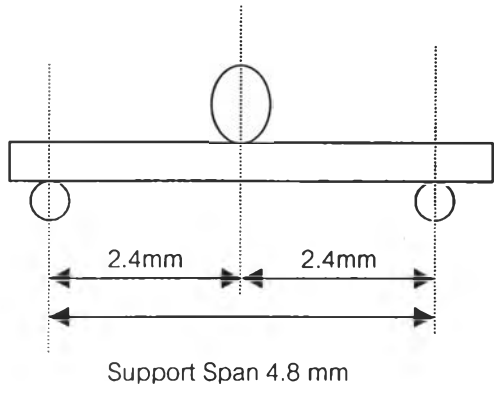


Figure B-1 Flexural strength by Three Point Loading

$$\text{Flexural strength } (N/mm^2) = \frac{3PL}{2bd^2}$$

where :

P	=	load at the given point on the load-deflection curve (N)
L	=	support span (mm)
b	=	width of specimen beam (mm)
d	=	thickness or depth of specimen (mm)

B3. Heat Distortion Temperature (ASTM 648-82)

Heat distortion temperature is a temperature that the test bar has deflected 0.26 mm. This temperature is recorded as the deflection temperature under flexural load of the test specimen.

The specimen is immersed under load in a heat-transfer medium provided with a means of raising the temperature at 2°C /min as shown in Figure B-2.

Unit: mm

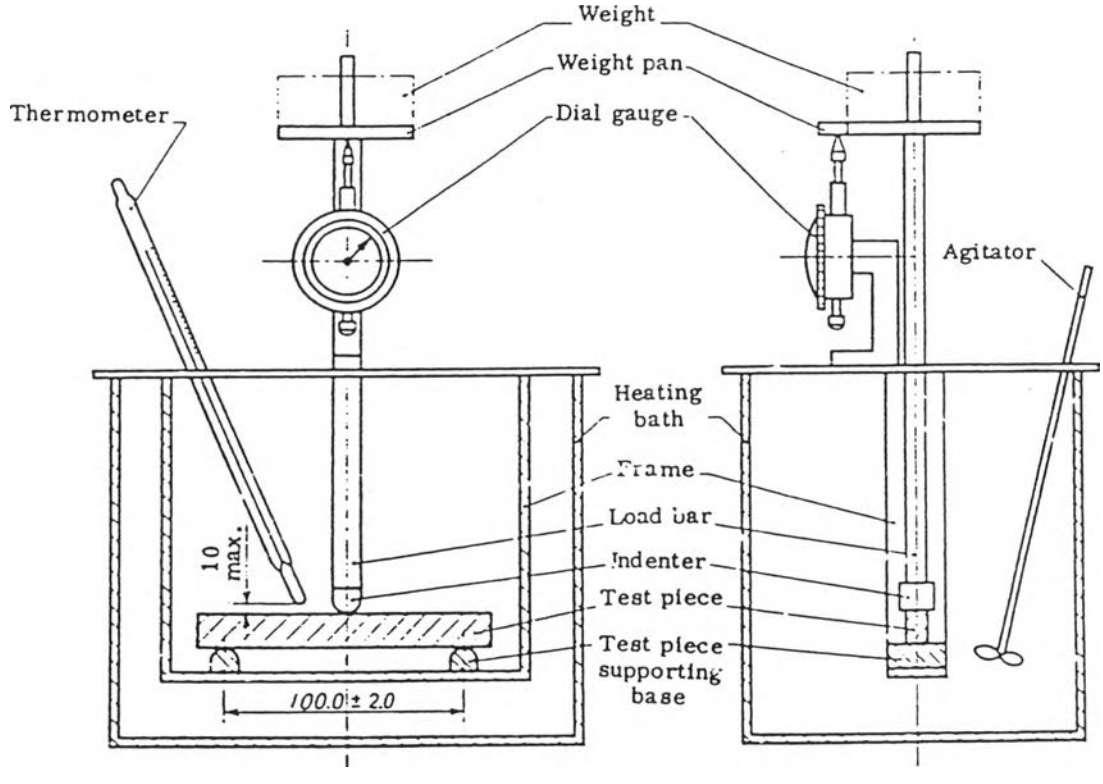


Figure B-2 Apparatus for heat distortion temperature test under Load

B4. Hardness (ASTM D785-93)

A Rockwell hardness number is number derived from the net increase in depth impression as the load on an indenter is increased from a fixed minor load to a major load and then returned to a minor load. In this study, Rockwell hardness scale is the following:

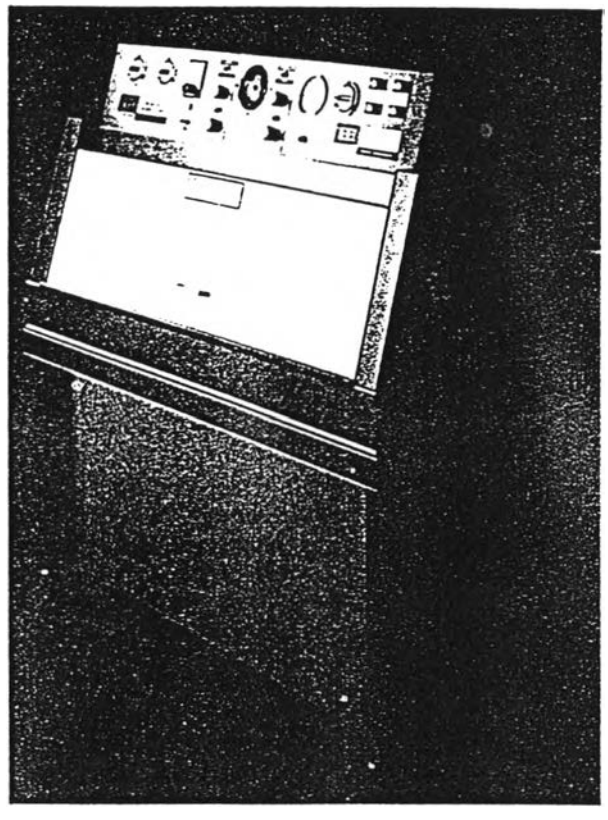
Rockwell Hardness Scale	Minor Load	Major Load	Indenter Diameter	
(Red Dial Numbers)	(kg)	(kg)	In.	mm.
M	10	100	0.2500	6.350

B5. Weathering Resistance (ASTM G53)

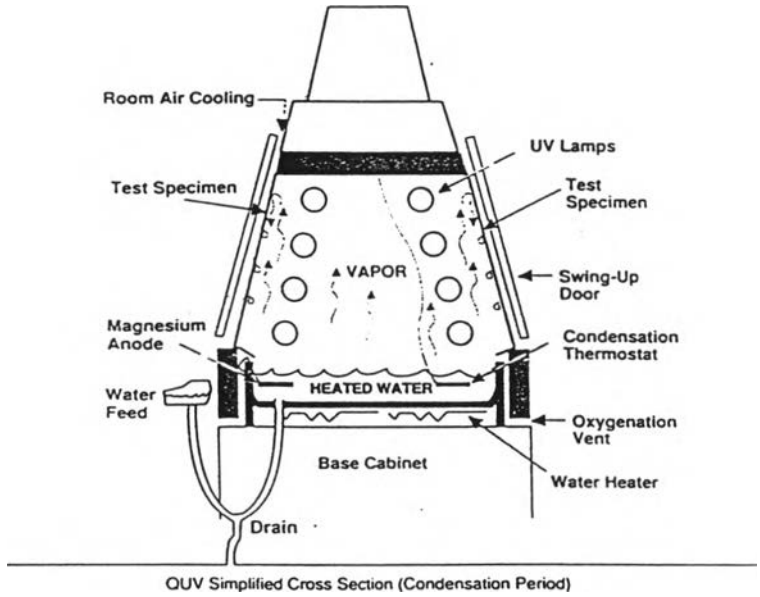
Weathering resistance is measured by the apparatus under this practice that is intended to simulate the deterioration caused by water as rain or dew and the ultraviolet energy in sunlight. Specimens are alternately exposed to ultraviolet light alone and to condensation alone in a repetitive cycle. The UV source is an array of fluorescent lamps, with lamp emission concentrated in the UV range. Condensation is produced by exposing the test surface to a heated, saturated mixture of air and water vapor, while the reverse side of the test specimen is exposed to the cooling influence of ambient room air.

Cycle of UV exposure time and temperature is 4 h UV at 60°C, 4 h condensation at 50°C and the test duration is 110 h in this study. The test specimens shall be mounted in stationary racks with the plane of the test surface parallel to the

plane of the lamps at a distance of 50 mm from the nearest surface of the lamps, as shown in Figure B-3.



The Q-U-V Accelerated Weathering Tester



QUV Simplified Cross Section (Condensation Period)

Figure B-3 Apparatus for weathering resistance test

APPENDIX C

Table C-1 Viscosity of orthophthalic and isophthalic UPR

Weight ratio of UP : SM : MMA	Viscosity (cps) , 25°C	
	Ortho UPR	Iso UPR
65 : 35 : 0	569	1100
65 : 30 : 5	523	957
65 : 25 : 10	479	960
65 : 20 : 15	433	838
65 : 15 : 20	421	904
65 : 10 : 25	409	823
65 : 0 : 35	332	721

Table C-2 Non-volatile content of orthophthalic and isophthalic UPR

Weight ratio of UP : SM : MMA	Non-volatile content (%)	
	Ortho UPR	Iso UPR
65 : 35 : 0	64.3	64.6
65 : 30 : 5	65.0	64.7
65 : 25 : 10	65.2	64.9
65 : 20 : 15	65.2	64.8
65 : 15 : 20	65.8	65.2
65 : 10 : 25	65.8	65.4
65 : 0 : 35	65.6	65.0

Table C-3 Acid Value of orthophthalic and isophthalic UPR

Weight ratio of UP : SM : MMA	Acid value (mg KOH/g)	
	Ortho UPR	Iso UPR
65 : 35 : 0	22.4	11.0
65 : 30 : 5	22.7	11.1
65 : 25 : 10	22.2	11.1
65 : 20 : 15	22.7	11.0
65 : 15 : 20	23.5	11.5
65 : 10 : 25	22.2	11.6
65 : 0 : 35	22.8	10.7

Table C-4 Gel time (Cup gel test) of orthophthalic and isophthalic UPR

Weight ratio of UP : SM : MMA	Gel time (min), 25°C, Co 0.2 wt%, MEKPO 1.0 wt%	
	Ortho UPR	Iso UPR
65 : 35 : 0	6.4	9.7
65 : 30 : 5	12.0	18.8
65 : 25 : 10	17.4	22.3
65 : 20 : 15	28.7	35.7
65 : 15 : 20	36.9	41.0
65 : 10 : 25	56.4	60.2
65 : 0 : 35	163.9	240

Table C-5 Gel time (SPI gel test) of orthophthalic and isophthalic UPR

Weight ratio of UP : SM : MMA	Gel time (min), 60°C, Co 0.2 wt%, MEKPO 1.0 wt%	
	Ortho UPR	Iso UPR
65 : 35 : 0	1.2	1.2
65 : 30 : 5	1.9	1.5
65 : 25 : 10	2.5	1.7
65 : 20 : 15	3.5	2.2
65 : 15 : 20	4.6	3.2
65 : 10 : 25	5.6	3.5
65 : 0 : 35	6.2	5.0

Table C-6 Cure time (SPI gel test) of orthophthalic and isophthalic UPR

Weight ratio of UP : SM : MMA	Cure time (min), 60°C, Co 0.2 wt%, MEKPO 1.0 wt%	
	Ortho UPR	Iso UPR
65 : 35 : 0	3.0	2.9
65 : 30 : 5	3.4	2.6
65 : 25 : 10	4.0	3.0
65 : 20 : 15	5.0	3.4
65 : 15 : 20	5.9	4.1
65 : 10 : 25	7.0	5.0
65 : 0 : 35	6.9	5.3

Table C-7 Exothermic peak temperature (SPI gel test) of orthophthalic and isophthalic UPR

Weight ratio of UP : SM : MMA	Exothermic peak temperature (°C), 60°C, Co 0.2 wt%, MEKPO 1.0 wt%	
	Ortho UPR	Iso UPR
65 : 35 : 0	154	170
65 : 30 : 5	158	180
65 : 25 : 10	156	175
65 : 20 : 15	142	165
65 : 15 : 20	125	130
65 : 10 : 25	117	125
65 : 0 : 35	95	96

Table C-8 Tensile strength of ortho UP thermoset polyester

Weight ratio of Ortho UP : SM : MMA	Tensile strength (N/mm^2)			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	39	36	38	38
65 : 30 : 5	34	36	40	40
65 : 25 : 10	36	35	36	36
65 : 20 : 15	34	36	36	35
65 : 15 : 20	37	34	35	35
65 : 10 : 25	21	28	30	26

Table C-9 Tensile strength of iso UP thermoset polyester

Weight ratio of Iso UP : SM : MMA	Tensile strength (N/mm^2)			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	31	38	34	39
65 : 30 : 5	41	39	35	44
65 : 25 : 10	33	41	35	40
65 : 20 : 15	39	38	43	38
65 : 15 : 20	47	48	50	49
65 : 10 : 25	41	36	40	42

Table C-10 Flexural strength of ortho UP thermoset polyester

Weight ratio of Ortho UP : SM : MMA	Flexural strength (N/mm^2)			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	74	70	82	80
65 : 30 : 5	75	63	65	94
65 : 25 : 10	75	69	69	69
65 : 20 : 15	70	76	70	66
65 : 15 : 20	72	67	75	70
65 : 10 : 25	57	57	81	70

Table C-11 Flexural strength of iso UP thermoset polyester

Weight ratio of Iso UP : SM : MMA	Flexural strength (N/mm^2)			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	82	97	90	80
65 : 30 : 5	98	94	100	92
65 : 25 : 10	91	99	100	84
65 : 20 : 15	82	81	95	96
65 : 15 : 20	101	102	88	92
65 : 10 : 25	91	102	96	107

Table C-12 Hardness of ortho UP thermoset polyester

Weight ratio of ortho UP : SM : MMA	Hardness			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	92	101	100	99
65 : 30 : 5	100	103	104	100
65 : 25 : 10	102	99	103	99
65 : 20 : 15	97	99	100	99
65 : 15 : 20	93	96	96	90
65 : 10 : 25	83	84	92	74

Table C-13 Hardness of iso UP thermoset polyester

Weight ratio of Iso UP : SM : MMA	Hardness			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	104	104	102	101
65 : 30 : 5	102	102	101	102
65 : 25 : 10	105	103	104	104
65 : 20 : 15	106	105	104	103
65 : 15 : 20	106	105	106	105
65 : 10 : 25	102	100	102	98

Table C-14 Heat distortion temperature of ortho UP thermoset polyester

Weight ratio of ortho UP : SM : MMA	Heat distortion temperature (^{o}C)			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	72	72	71	90
65 : 30 : 5	86	84	82	80
65 : 25 : 10	68	65	63	72
65 : 20 : 15	66	59	58	58
65 : 15 : 20	53	51	49	59
65 : 10 : 25	53	58	50	55

Table C-15 Heat distortion temperature of iso UP thermoset polyester

Weight ratio of Iso UP : SM : MMA	Heat distortion temperature (°C)			
	Amount of MEKPO (% v/wt)			
	0.5	1.0	1.5	2.0
65 : 35 : 0	89	90	110	104
65 : 30 : 5	74	105	107	80
65 : 25 : 10	92	76	75	92
65 : 20 : 15	86	72	74	72
65 : 15 : 20	71	85	70	69
65 : 10 : 25	61	62	70	55

VITA

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