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APPENDICES

Appendix A: Physical and chemical properties of material used

The following tables show the chemical and physical properties and the suppliers of the materials used.

Table A1: Physical and chemical properties of urea

Property	Unit	Value
Melting point	°C	133
pH of water solution	pH	7,1-8,4
Density	g/cm^3	1,34
Vapour pressure	hPa	0,1
Thermal decomposition	°C	134

Table A2: Physical and chemical properties of two types of PVOH

Property	Unit	Partially hydrolysed PVOH	Fully hydrolysed PVOH
Melting point	°C	180-190	200-230
pH	pH	4,5-6,5	5,5-7,0
Degree of hydrolysis	%	87-89	98-98,8
Bulk density	kg/m^3	640	640
Viscosity @ 4% solution	cps	45-55	3,5-4,5
Ash content	%	0,5	1,2

Table A3: Physical and chemical properties of paraffin wax compounds

Property	Unit	M3X	M3E	SRW
Melting	°C	60-65	60-66	58-62
Penetration	0,1 mm	17-24	10-18	10-18
Oil content	%	2,4-3,4	1,5 max	1,5 max
Saybolt colour	minutes	10 min	20 min	1,5 max

Table A4: Physical properties of ethylene vinyl acetate (EVA) copolymers

Property	EVA 210	EVA 410	EVA 265	Unit
Melt index	400	500	3,0	dg/min
Vinyl acetate	28	18	28	%
Density at 23°C	951	934	955	g/m^3
Tensile strength	2,8	4,7	29	MPa
Elongation at break	800-1 000	600-900	800-1 000	%
Elastic (tensile) modulus	12	33	28	MPa
Hardness	62	80	83	seconds
Softening point (ring & ball)	82	88	171	°C
Cloud point in paraffin wax	66	66	66	°C

Table A5: Physical and chemical properties of glycerol

Property	Unit	Value
Melting point	°C	18
Solubility	-	Soluble in water
Boiling point	°C	290
Bulk density	kg/m^3	1,26
Vapour density	cps	3,17

Table A6: Suppliers and grades of material used

Material	Supplier	Grade
Ethylene vinyl acetate	Dupont	EVA210
Polyvinyl alcohol	Celanese	Celvol 540
Wax	Sasol Schumann	Paraffin M3X
Urea	Algro Brits	Fertilizer grade
Glycerol	Promark chemicals	CP grade

Appendix B: Specifications of processing and characterisation equipment

The following tables show the specifications of the processing and characterisation equipment used.

Table B1: Processing equipment specifications

Equipment	Uses	Machine & Specification
Two-roll mill	Compounding	Bridge, max. spinning speed 30 r/min Roll space 0,025-0,25 inch
Single-screw extruder	Compounding	Rapra, 25 mm screw diameter Output 5 k/h
Twin-screw co-rotating intermeshing extruder	Compounding	Berstoff, Max output 120 k/h Screw diameter 40 mm Screw speed 0-500 r/min
Injection moulder	Pattern production	Engel, max. clamp force 800 kN Max. pressure 200 bars, Screw diameter 40 mm, Max injection speed 113 mm/s

Table B2: Specifications of characterisation equipment

Equipment	Characterisation parameter	Instrument specification
Three-point test	Mechanical properties: load/deflection, work done, modulus of rupture, Young's modulus of bending	Lloyd instrument: load capacity 5 kN
Impact tester	Mechanical properties: impact strength	Zwick Hammer load 10-40 kpcm
Differential scanning calorimeter	Thermal properties: melting temperature, crystallisation temperature, heat of melting	Perkin Elmer DSC 7
Differential thermal analysis	Thermal properties: melting temperature, heat of melting	Mettler Toledo
Dynamic mechanical analysis	Viscoelastic properties: storage and loss modulus, loss tangent, linear thermal expansion coefficient	Perkin Elmer DMA 7e Modulus: 10^4 to 10^{12} Frequency 0,01 to 51 Hz
Thermogravimetric analysis	Thermal decomposition: mass loss	Mettler Toledo

Appendix C: Processing conditions for compounding and injection moulding

Table C1: Twin-screw extruder compounding trials on EVA-urea-based pattern

	Temperature profile (°C)				**Amps**	**Screw speed**
	T_1 (hopper)	**T_2**	**T_3**	**T_4 (die)**	**A**	**(r/min)**
UE 80:15:5	106	102	103	105	15	102
UE 80:10:10	101	102	103	105	12	106
UE 80:5:15	102	103	104	105	18	108
UE 75:20:5	101	102	104	107	15	105
UE 75:15:10	102	103	104	105	18	107
UE 75:10:15	106	107	103	108	12	106
UE 70:25:5	109	103	102	108	18	107
UE 70:20:10	105	105	104	109	15	105
UE 70:15:15	102	103	104	105	18	107

Table C2: Two-roll mill compounding conditions of PVOH urea-based patterns

Temperature profile (°C)		
T_1 (Roll 1)	T_2 (Roll 2)	**(r/min)**
110	110	15

Table C3: Overall injection moulding conditions of urea-based compounds

Urea moulding compounds	Temperature profile (°C)				Injection speed (mm/s)	Cooling time (s)	Injection pressure (bar)
	T_1 (hopper)	T_2	T_3	T_4 (die)			
UEVA	100	100	100	105	25	15	90
UP8	100	103	100	106	20	15	90
UP4	105	105	105	110	25	15	90
Cooked (benchmark)	90	90	95	100	20	15	90

Appendix D: Experimental procedure for producing cooked urea-based moulding compounds

1. Add 30 l of water and 150 kg of urea to each of the two pots.
2. Heat content to 125°C.
3. Parallel to the above; add 40 l of water, 15 kg of Moviol 40-88 (PVA), 10 kg of urea and 10 l of spirits to the small pot and heat to 90°C.
4. When the urea and water mixture reaches 125°C, add 125 ml of antifoam (Silfoame 212F).
5. When the urea and water mixture reaches 130°C, add half of the contents of the small pot to each of the two bigger pots.
6. Heat to 150°C.
7. Add 800 ml of glycerine and 1,5 kg of Sasol A1 wax.
8. Heat to 164°C and tap off.

Appendix E: Property values of cooked urea moulding compound (benchmark)

Property	Unit	Value	Standard deviation	Method
Mechanical properties				
Maximum load	N	61,2	2,12	ASTM D790
Maximum deflection	mm	1,58	0,16	ASTM D790
Flexural stress	MPa	37,0	1,3	ASTM D790
Flexural strain	%	0,92	0,09	ASTM D790
Modulus of elasticity	GPa	8,5	0,36	ASTM D790
Fracture energy	mJ	67,7	12,6	ASTM D790
Charpy impact strength	kJ/m^2	0,56	0,13	ISO 180
Thermal properties				
Melting temperature	°C	107,0	-	DSC
Mass loss at temperature:	°C			TGA
95% Mass loss		418		
97% Mass loss		472		
Flow properties				
Melt flow index	dg/min@110°C	44,5	6,87	ASTM 1238
Thermal mechanical properties				
Linear thermal expansion coefficient	10^{-6} °C	120,6	-	TMA
Vicat softening temperature	°C	57,2		TMA
Density @ 25 °C	kg/m^3	1120		

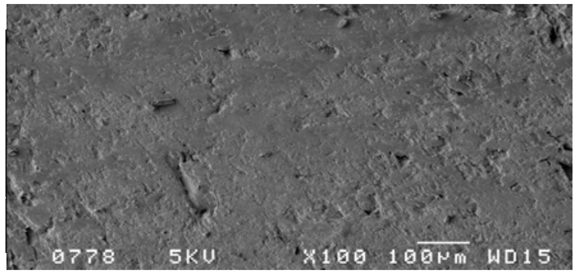

Figure E1: SEM surface photograph of cooked urea moulding compound

Appendix F: Mechanical property data on urea moulding compounds

Table F1: Charpy impact test data for PVOH (80 phr glycerol) moulding compounds

Urea:PVOH8:wax	$Z_0 \pm SZ_0$ (N)	$W_h \pm SW_h$ (mm)	$T_s \pm ST_s$ (mm)	F± SF (J)	$I_s \pm SI_s$ (kJ/m^2)
90:5:5	1,33	4,194 ± 0,011	10,068 ± 0,013	5,39 ± 0,50	0,96 ± 0,12
85:10:5	1,33	4,178 ± 0,010	10,062 ± 0,008	14,6 ± 0,82	3,16 ± 0,20
80:15:5	1,33	4,192 ± 0,004	10,090 ± 0,025	23,4 ± 3,49	5,24 ± 0,82
85:5:10	1,33	4,168 ± 0,017	10,038 ± 0,026	4,14 ± 0,38	0,67 ± 0,09
80:10:10	1,33	4,174 ± 0,013	10,068 ± 0,008	7,73 ± 0,33	1,52 ± 0,07
75:15:10	1,33	4,182 ± 0,011	10,076 ± 0,005	14,5 ± 2,42	3,12 ± 0,58
80:5:15	1,33	4,160 ± 0,012	10,070 ± 0,100	3,17 ± 0,78	0,44 ± 0,19
75:10:15	1,33	4,140 ± 0,025	10,034 ± 0,032	5,87 ± 0,98	1,09 ± 0,24
70:15:15	1,33	4,152 ± 0,019	10,048 ± 0,016	10,2 ± 0,91	2,21 ± 0,22

Table F2: Charpy impact test data for PVOH (40 phr glycerol) moulding compounds

Urea:PVOH:wax	$Z_0 \pm SZ_0$ (N)	$W_h \pm SW_h$ (mm)	$T_s \pm ST_s$ (mm)	F± SF (J)	$I_s \pm SI_s$ (kJ/m^2)
90:5:5	1,33	4,130 ± 0,015	10,006 ± 0,015	4,81 ± 0,64	0,84 ± 0,15
85:10:5	1,33	4,180 ± 0,012	10,096 ± 0,026	5,12 ± 0,49	0,90 ± 0,12
80:15:5	1,33	4,180 ± 0,005	10,112 ± 0,031	8,41 ± 0,30	1,67 ± 0,10
85:5:10	1,33	4,193 ± 0,014	10,064 ± 0,026	3,65 ± 0,72	0,55 ± 0,17
80:10:10	1,33	4,190 ± 0,017	10,096 ± 0,017	5,06 ± 0,60	0,88± 0,14
75:15:10	1,33	4,182 ± 0,025	10,084 ± 0,005	7,47 ± 2,08	1,46 ± 0,50
80:5:15	1,33	4,204 ± 0,028	10,086 ± 0,023	3,47 ± 0,45	0,50 ± 0,10
75:10:15	1,33	4,204 ± 0,029	10,082 ± 0,024	5,84 ± 0,31	1,06 ± 0,07
70:15:15	1,33	4,144± 0,009	10,068 ± 0,048	7,34 ± 0,44	1,44 ± 0,10

Table F3: Charpy impact test data for EVA moulding compounds

Urea:EVA:wax	$Z_0 \pm SZ_0$ (N)	$W_h \pm SW_h$ (mm)	$T_s \pm ST_s$ (mm)	F± SF (J)	$I_s \pm SI_s$ (kJ/m^2)
80:15:5	1,33	4,184 ± 0,027	10,042 ± 0,058	4,746 ± 0,691	0,81 ± 0,16
75:20:5	1,33	4,162 ± 0,001	10,048 ± 0,030	8,433 ± 1,105	1,70 ± 0,27
70:25:5	1,33	4,160 ± 0,007	10,020 ± 0,046	9,630 ± 1,630	1,99 ± 0,39
65:30:5	1,33	4,164 ± 0,005	10,050 ± 0,001	14,14 ± 1,770	3,06 ± 0,43
80:10:10	1,33	4,204 ± 0,015	10,040 ± 0,022	4,214 ± 0,850	0,68 ± 0,20
70:20:10	1,33	4,158 ± 0,003	10,002 ± 0,030	9,453 ± 2,102	1,95 ± 0,51
65:25:10	1,33	4,120 ± 0,007	10,096 ± 0,008	11,51 ± 0,590	2,45 ± 0,14
60:30:10	1,33	4,166 ± 0,011	10,008 ± 0,006	10,43 ± 1,537	2,18 ± 0,36
80:5:15	1,33	4,160 ± 0,021	9,992 ± 0,032	2,235 ± 0,435	0,22 ± 0,11
75:10:15	1,33	4,162 ± 0,083	10,032 ± 0,033	4,550 ± 0,413	0,77 ± 0,10
70:15:15	1,33	4,178 ± 0,015	10,060 ± 0,012	5,648 ± 0,377	1,03 ± 0,09
70:20:15	1,33	4,166± 0,011	10,016 ± 0,054	9,806 ± 1,419	2,03 ± 0,13

Table F4: Three-point bending test data for PVOH (80 phr glycerol) moulding compounds

Urea:PVOH:wax	$M_L \pm SM_L$ (N)	$M_D \pm SM_D$ (mm)	$\varepsilon_b \pm S\varepsilon_b$ (%)	$E \pm SE$ (GPa)	$M_R \pm SM_R$ (MPa)	$W_D \pm SW_D$ (MPa)
90:5:5	55,49 ± 1,12	1,26 ± 0,13	0,0074 ± 0,83	10,07 ± 0,69	33,24 ± 0,72	49,54 ± 10,43
85:10:5	35,91 ± 1,90	3,79 ± 0,29	0,0233 ± 0,21	6,06 ± 0,28	21,54 ± 1,14	107,89 ± 13,92
80:15:5	31,08 ± 0,93	6,89 ± 0,44	0,0404 ± 0,12	4,23 ± 0,28	18,65 ± 0,56	148,55 ± 1,46
85:5:10	60,95 ± 3,11	1,35 ± 0,13	0,0078 ± 0,58	10,14 ± 0,64	36,98 ± 1,76	53,59 ± 8,66
80:10:10	33,76 ± 1,59	2,77 ± 0,16	0,0163 ± 0,07	6,00 ± 0,43	20,26 ± 0,95	71,17 ± 7,71
75:15:10	28,14 ± 1,17	5,69 ± 0,41	0,0333 ± 0,09	3,36 ± 0,46	16,89 ± 0,71	119,19 ± 16,08
80:5:15	60,29 ± 2,13	1,31 ± 0,12	0,0076 ± 0,21	9,06 ± 0,76	36,17 ± 1,28	49,25 ± 8,18
75:10:15	37,04 ± 4,97	2,91 ± 0,65	0,0271 ± 0,24	6,03 ± 0,67	22,22 ± 2,98	72,99 ± 12,38
70:15:15	30,92 ± 0,80	4,98 ± 0,66	0,0292 ± 0,19	4,04 ± 0,35	18,55 ± 0,48	113,95 ± 23,13

Table F5: Three-point bending test data for PVOH (40 phr glycerol) moulding compounds

Urea:PVOH:wax	M_L± SM_L (N)	M_D ± SM_D (mm)	ε_b ± $S\varepsilon_b$ (%)	E ± SE (GPa)	M_R ± SM_R (MPa)	W_D ± SW_D (MPa)
90:5:5	79,60± 2,21	1,40± 0,12	0,0074± 0,15	11,39±0,26	47,76± 1,33	71,44± 11,43
85:10:5	61,72± 1,93	2,22± 0,36	0,0134± 0,12	9,08± 0,82	37,03 ± 1,16	97,47 ± 11,92
80:15:5	61,85± 1,90	3,56± 0,13	0,0208± 0,10	8,12± 0,47	37,11± 1,14	155,50±1,46
85:5:10	81,62± 5,5	1,55 ± 0,27	0,0091± 0,17	11,32± 0,95	48,97± 3,33	84,38 ± 8,66
80:10:10	61,77± 1,70	1,29± 0,28	0,0076 ± 0,14	10,38± 0,86	37,06± 1,02	51,22± 7,71
75:15:10	48,07± 2,84	2,27 ± 0,12	0,0133± 0,50	6,68± 0,60	28,84± 1,70	72,30± 16,08
80:5:15	81,20± 3,56	1,37 ± 0,28	0,0080± 0,10	10,65± 0,82	48,72± 2,13	66,04± 8,18
75:10:15	63,13± 1,54	2,23± 0,12	0,0136± 0,07	9,16± 0,64	37,87± 0,92	80,26± 12,38
70:15:15	45,40± 2,99	2,82± 0,54	0,0165± 0,10	5,24± 0,43	27,24± 1,80	86,58± 23,13

Table F6: Three-point bending test data for EVA moulding compounds

Urea:EVA:wax	$M_L \pm SM_L$ (N)	$M_D \pm SM_D$ (mm)	$\varepsilon_b \pm S\varepsilon_b$ (%)	$E \pm SE$ (GPa)	$M_R \pm SM_R$ (MPa)	$W_D \pm SW_D$ (MPa)
80:15:5	29,45±1,58	0,62± 0,04	0,0036± 0,21	7,71±1,13	17,67± 0,95	9,53± 0,70
75:20:5	16,84± 0,27	1,17± 0,06	0,0069± 0,33	3,83± 0,75	10,11 ± 0,16	12,90 ± 0,88
70:25:5	13,74± 0,14	1,77± 0,09	0,0104± 0,50	2,21± 0,08	8,25± 0,08	16,06±0,66
65:30:5	11,65± 0,34	2,52± 0,09	0,0148± 0,50	1,26± 0,04	6,99± 0,20	20,79 ± 1,16
80:10:10	29,93± 1,58	0,54± 0,02	0,0031± 0,14	8,51± 0,57	17,96± 0,95	8,50± 0,59
70:20:10	21,23± 0,34	0,90± 0,09	0,0081± 0,50	3,43± 0,77	9,15± 0,41	14,37± 1,03
65:25:10	15,25± 0,69	1,39± 0,05	0,0089± 0,03	1,86± 0,16	8,25± 0,08	18,05± 1,25
60:30:10	11,62± 0,15	2,25± 0,03	0,0171± 0,17	1,24± 0,16	7,42± 0,15	23,63± 0,79
80:5:15	12,26± 0,05	2,95± 0,38	0,0066± 0,10	6,30± 0,9	18,43± 1,10	7,84± 0,64
75:10:15	24,57± 1,46	0,75± 0,11	0,0108± 0,08	4,61± 0,57	13,92± 0,36	11,84± 0,58
70:15:15	23,20± 0,60	1,20± 0,08	0,0256± 0,06	1,76± 0,34	12,04± 0,87	19,84± 1,89
65:20:15	17,13± 0,42	2,86±0,10	0,0356± 0,06	1,22± 0,08	10,28± 0,25	22,24± 1,18

Appendix G: Matlab script for performing two-way ANOVA

Appendix G1: Matlab script file for performing two-way ANOVA on the Charpy impact test data obtained with urea-wax- PVOH (80 phr of glycerol) compounds

```
%-------- Script file for 2-way analysis of impact strength----------
%
% Charpy data for urea-PVOH-wax
% PVOH contains 80phr glycerol
%
% Response variable = ln(Charpy impact (unnotched)in kJ/m2)
%
% Hilary Rutto 9 April 2006
% Last time modified 9 April 2006
%
% *********************************************************************
%
%
% The purpose is to determine the effect of wax and polymer content on the
% Charpy impact strength of the pattern material,
%
% Three different wax levels (5%, 10% & 15%) were considered (columns),
% Three different polymer levels (5%, 10% & 15%) were considered (rows)
%
% Five replicates at each composition were tested
% Thus there are a total of 15 rows and three columns in the data set
%
% Initialize the number of wax levels:
PVOH = [0,050   0,050   0,050   0,050   0,050   0,050   0,050   0,050,,,
    0,050   0,050   0,050   0,050   0,050   0,050   0,050   0,100,,,
    0,100   0,100   0,100   0,100   0,100   0,100   0,100   0,100,,,
```

```
   0,100   0,100   0,100   0,100   0,100   0,100   0,150   0,150,,,
   0,150   0,150   0,150   0,150   0,150   0,150   0,150   0,150,,,
   0,150   0,150   0,150   0,150   0,150];
%
wax = [0,0500   0,0500  0,0500  0,0500  0,0500  0,1000  0,1000  0,1000,,,
   0,1000  0,1000  0,1500  0,1500  0,1500  0,1500  0,1500  0,0500,,,
   0,0500  0,0500  0,0500  0,0500  0,1000  0,1000  0,1000  0,1000,,,
   0,1000  0,1500  0,1500  0,1500  0,1500  0,1500  0,0500  0,0500,,,
   0,0500  0,0500  0,0500  0,1000  0,1000  0,1000  0,1000  0,1000,,,
   0,1500  0,1500  0,1500  0,1500  0,1500];
% Enter the experimental Charpy data
%
CharpyUP8 =[-0,113  -0,138  0,094   -0,143  0,075   -0,514  -0,485,,,
   -0,402 -0,445   -0,189  -1,019  -1,904  -0,519  -0,643  -0,559,,,
   1,089   1,170   1,086   1,235   1,164   0,421   0,331   0,450,,,
   0,440   0,451   -0,189 -0,150   0,281   0,122   0,272   1,814,,,
   1,664   1,783   1,514   1,455   0,914   1,362   1,009   1,086,,,
   1,257   0,804   0,825   0,722   0,817   0,578];
%
varnames ={'Wax level','PVOH level'}
% The ANOVA table has columns for the sums of squares, degrees-of-freedom,
% mean squares (SS/df), F statistics, and p-values,
%
% Generate the ANOVA table for the Charpy data
[p,tbl,stats] = ANOVAn(CharpyUP8,{wax PVOH},2,3,varnames);
%
```

Appendix G2: Matlab script file for performing multiple linear regression on the Charpy impact test data obtained with urea-wax-PVOH (80 phr of glycerol) compounds

```
%
%-------- Script file for 2-way analysis of impact strength----------
%
% Charpy data for urea-PVOH-wax
% PVOH contains 80phr glycerol
%
% Charpy impact (unnotched)in kJ/m2
%
% Hilary Rutto 9 April 2006
% Last time modified 9 April 2006
%
% ************************************************************************
%
%
% The purpose is to determine the effect of wax and polymer content on the
% Charpy impact strength of the pattern material,
%
% Three different wax levels (5%, 10% & 15%) were considered (columns),
% Three different polymer levels (5%, 10% & 15%) were considered (rows)
%
% Five replicates at each composition were tested
% Thus there are a total of 15 rows and three columns in the data set
%
% Now do linear regression
% Data set for linear regression
% Data matrix has a column of ones, and then one column of values for each
% of the predictor variables, The column of ones is necessary for
% estimating the y-intercept of the linear model, The last column gives the
```

```
% Charpy impact strength values
%
Data =[1    0,050   0,0500  -0,113
1   0,050   0,0500  -0,138
1   0,050   0,0500  0,094
1   0,050   0,0500  -0,143
1   0,050   0,0500  0,075
1   0,050   0,1000  -0,514
1   0,050   0,1000  -0,485
1   0,050   0,1000  -0,402
1   0,050   0,1000  -0,445
1   0,050   0,1000  -0,189
1   0,050   0,1500  -1,019
1   0,050   0,1500  -1,904
1   0,050   0,1500  -0,519
1   0,050   0,1500  -0,643
1   0,050   0,1500  -0,559
1   0,100   0,0500  1,089
1   0,100   0,0500  1,170
1   0,100   0,0500  1,086
1   0,100   0,0500  1,235
1   0,100   0,0500  1,164
1   0,100   0,1000  0,421
1   0,100   0,1000  0,331
1   0,100   0,1000  0,450
1   0,100   0,1000  0,440
1   0,100   0,1000  0,451
1   0,100   0,1500  -0,189
1   0,100   0,1500  -0,150
1   0,100   0,1500  0,281
1   0,100   0,1500  0,122
1   0,100   0,1500  0,272
```

```
1   0,150   0,0500  1,814
1   0,150   0,0500  1,664
1   0,150   0,0500  1,783
1   0,150   0,0500  1,514
1   0,150   0,0500  1,455
1   0,150   0,1000  0,914
1   0,150   0,1000  1,362
1   0,150   0,1000  1,009
1   0,150   0,1000  1,086
1   0,150   0,1000  1,257
1   0,150   0,1500  0,804
1   0,150   0,1500  0,825
1   0,150   0,1500  0,722
1   0,150   0,1500  0,817
1   0,150   0,1500  0,578
];
%
% Set up the linear regression model
%
X = Data(:,1:3);
y = Data(:,4);
[b,bint,r,rint,stats] = regress(y,X);
%
% The y-intercept is b(1)
% It corresponds to the column index of the column of ones
%
% The elements of the vector stats are the regression R2 statistic, the F
% statistic (for the hypothesis test that all the regression coefficients
% are zero), and the p-value associated with this F statistic,
%
stats
%
```

```
% Scatter plot for the residuals
% The scatter plot shows the residuals plotted in case order (by row),
% The error bars indicate 95% confidence intervals about these residuals
% Outlier observation have error bars that do not cross the zero reference line
rcoplot(r,rint)
%
```

Appendix H: Experimental procedure for measuring density using Archimedes' principle

Calculation of density using Archimedes' principle

1. Mass of the liquid = [mass of liquid in pyconometer + liquid – mass of pyconometer]

2. Mass of undisplaced immersed liquid = [mass of liquid in pyconometer + polymer – mass of polymer blend – mass of pyconometer]

3. Mass of displaced immersed liquid = [mass of liquid in pyconometer –- mass of undisplaced immersed liquid]

4. Volume of the polymer blend = [mass of displaced liquid/theoretical density of liquid]

5. Density of the polymer blend = [mass of dry polymer blend/volume of the polymer blend]