

UF urea-formaldehyde resin

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	urea-formaldehyde resin	
CAS name	-	urea, polymer with formaldehyde	
Acronym	-	UF	
CAS number	-	9011-05-6; 68611-64-3; 68071-45-4	
HISTORY			
Person to discover	-	Ellis, C	Ellis, C, US Patent 1,846,853, Feb. 23, 1932.
Date	-	1932 (filled 1924)	
Details	-	reaction between urea and formaldehyde in the presence of alkaline catalyst	
SYNTHESIS			
Monomer(s) structure	-	$ \begin{array}{ccc} & \text{O} & \text{O} \\ & \parallel & \parallel \\ \text{H}_2\text{N} & -\text{C}- & \text{C}-\text{H} \\ & \parallel & \parallel \\ & \text{NH}_2 & \text{H} \end{array} $	
Monomer(s) CAS number(s)	-	57-13-6; 50-00-0	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	60.06; 30.03	
Monomer ratio	-	1-1.6 (F/U)	Park, B-D; Jeong, H-W; Int. J. Adhesion Adhesives, in press, 2011.
Method of synthesis	-	reaction of urea with formaldehyde dissolved in water (45-50% solution) to hydroxymethylated urea used for subsequent polycondensation	
Temperature of curing	°C	90-120	Minopoulou, E; Dessipri, E; Chrysosikos, G D; Gionis, V; Paipetis, A; Panayiotou, C, Int. J. Adhesion Adhesives, 23, 473-84, 2003.
Gelation time	s	51-201	Park, B-D; Jeong, H-W; Int. J. Adhesion Adhesives, in press, 2011.
Number average molecular weight, M_n	dalton, g/mol, amu	400-640 (water based dispersion)	Ferra, J M M; Mendes, A M; Costa, M R N; Carvalho, L H, J. Appl. Polym. Sci., 118, 1956-68, 2010.
Mass average molecular weight, M_w	dalton, g/mol, amu	2,500-500,000 (water based dispersion)	Gavrilovic-Grmusa, I; Neskovic, O; Diporovic-Momcilovic, M; Popovic, M, J. Serb. Chem. Soc., 75, 5, 689-701, 2010.
Polydispersity, M_w/M_n	-	5.2-7.3 (water based dispersion)	
COMMERCIAL POLYMERS			
Some manufacturers	-	Chemiplastica	
Trade names	-	Urochem	
PHYSICAL PROPERTIES			
Density at 20°C	g cm ⁻³	1.2-1.31	
Refractive index, 20°C	-	1.43	
Melting temperature, DSC	°C	119	
Heat deflection temperature at 1.8 MPa	°C	130	
Hansen solubility parameters, δ_D , δ_P , δ_H	MPa ^{0.5}	20.81, 8.29, 12.71	

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Hildebrand solubility parameter	MPa ^{0.5}	25.74	
Dielectric constant at 100 Hz/1 MHz	-	5	
Dissipation factor at 1000 Hz	E-4	1000	
Volume resistivity	ohm-m	1.1E9	
Surface resistivity	ohm	1.1E11	
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	55	
Tensile stress at yield	MPa	45-55	
Flexural strength	MPa	80-170	
Charpy impact strength, unnotched, 23°C	kJ m ⁻²	5-12	
Charpy impact strength, notched, 23°C	kJ m ⁻²	1.1-1.6	
Tenacity (fiber)	cN tex ⁻¹	14	Rogers-Gentile, V; East, G C, McIntyre, J E; Snowden, P, J. Appl. Polym. Sci., 77, 64-74, 2000.
Shrinkage	%	0.8-1.4	
Melt viscosity, shear rate=1000 s ⁻¹	mPa s	248-327; 150-350 (63-64% water emulsion)	Park, B-D; Jeong, H-W; Int. J. Adhesion Adhesives, in press, 2011.
Water absorption, equilibrium in water at 23°C	%	3	
FLAMMABILITY			
Flammability according to UL-94 standard; thickness 1.6/0.8 mm	class	V-0	
Ignition temperature	°C	>200	
Autoignition temperature	°C	393	
Limiting oxygen index	% O ₂	30	
Char at 500°C	%	10	
Volatile products of combustion	-	H ₂ O, CO ₂ , CO, NH ₃ , CH ₄ , HNCO, HCN	Jiang, X; Li, C; Chi, Y; Yan, J, J. Hazardous Mater., 173, 205-10, 2010.
TOXICITY			
Oral rat, LD ₅₀	mg kg ⁻¹	8,394	
Skin rabbit, LD ₅₀	mg kg ⁻¹	>2,000	
ENVIRONMENTAL IMPACT			
Aquatic toxicity, Daphnia magna, LC ₅₀ , 48 h	mg l ⁻¹	>1,000	
Aquatic toxicity, Bluegill sunfish, LC ₅₀ , 48 h	mg l ⁻¹	>1,000	
Cradle to grave non-renewable energy use	MJ/kg	85.9	Harding, K G; Dennis, J S; von Blottnitz, H; Harrison, S T L, J. Biotechnol., 130, 57-66, 2007.

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PROCESSING			
Typical processing methods	-	injection molding	
Processing temperature	°C	145-150 (mold); 95-115 (nozzle)	
Processing pressure	MPa	70-150 (injection); 30-80 (holding); 10-14 (back)	
Additives used in final products	-	Hardeners: ammonium chloride, ammonium sulfate, ammonium citrate, and zinc nitrate	
Applications	-	fiber, fireboard, particle board, plywood	Flores, J A; Pastor, J J; Martinez-Gabarron, A; Gimeno-Blanes, F J; Rodriguez-Guisado, I; Frutos, M J, Ind. Crops Prod., in press, 2011.
Outstanding properties	-	gloss, low water resistance, scratch resistance	
ANALYSIS			
FTIR (wavenumber-assignment)	cm ⁻¹ /-	N-H – 3350-3340, 900-650, 750-700; O-CH ₃ – 2962-2960; C=O – 1654-46; C-N – 1560-50, 1260-1250, 1050-1030; C-H – 1465-1440, 1400-1380	Park, B-D; Kim, Y S; Singh, A P; Lim, K P, J. Appl. Polym. Sci., 88, 2677-87, 2003.
Raman (wavenumber-assignment)	cm ⁻¹ /-	N-H – 3300-3450; CH ₂ – 2950-3020; C=O – 1650-1640; CN – 1180-1160, 1030-990, 920-890	Minopoulou, E; Dessipri, E; Chrysikos, G D; Gionis, V; Paipetis, A; Panayiotou, C, Int. J. Adhesion Adhesives, 23, 473-84, 2003.
NMR (chemical shifts)	ppm	¹³ C chemical shifts	Christjanson, P; Pehk, T; Siimer, K, Proc. Estonian Acad. Sci. Chem., 55, 4, 212-25, 2006; Park, B-D; Kim, Y S; Singh, A P; Lim, K P, J. Appl. Polym. Sci., 88, 2677-87, 2003.
x-ray diffraction peaks	degree	21.5, 25, 31, 40.5	Park, B-D; Jeong, H-W; Int. J. Adhesion Adhesives, in press, 2011.