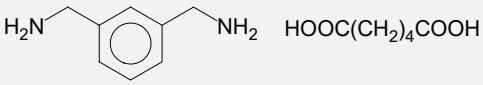
PARA polyamide MXD6

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	polyamide MXD6, nylon MXD6, polyarylamide, hexanedioic acid polymer with 1,3-benzenedimethanamine	
ACS name	-	poly[iminomethylene-1,3-phenylenemethyleneimino(1,6-dioxo-1,6-hexanediyl)]	
Acronym	-	PARA	
CAS number	-	25805-74-7 (MXD6); 902465-02-5 (IXEF 300); 1008793-20-1 IXEF 2060)	
HISTORY			
Person to discover	-	Caldwell J R; Gilkey, R	Caldwell J R; Gilkey, R, US Patent 2,916,476, Eastman Kodak, Dec. 8, 1959.
Date	-	1959	
Details	-	polyamides of xylidenediamine and aliphatic dibasic acids	
SYNTHESIS			
Monomer(s) structure	-		
Monomer(s) CAS number(s)	-	1477-55-0; 124-04-9	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	136.20; 146.14	
Monomer ratio	-	0.93 (0.93:1)	
Method of synthesis	-	polycondensation of m-xylenediamine with adipic acid	
STRUCTURE			
Crystallinity	%	35	
Cell type (lattice)	-	triclinic	Ota, T; Yamashita, M; Yoshizaki, O; Nagai, E, J. Polym. Sci., A-2, 4, 959, 1966.
Cell dimensions	nm	a:b:c=1.201:0.483:2.98	Ota, T; Yamashita, M; Yoshizaki, O; Nagai, E, J. Polym. Sci., A-2, 4, 959, 1966.
Unit cell angles	degree	α:β:γ=75:26:65	Ota, T; Yamashita, M; Yoshizaki, O; Nagai, E, J. Polym. Sci., A-2, 4, 959, 1966.
Number of chains per unit cell	-	2	
COMMERCIAL POLYMERS			
Some manufacturers	-	Mitsubishi Chemical; Solvay	
Trade names	-	Reny; Ixef	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	1.20-1.23; 1.19 (amorphous), 1.25 (crystalline); 1.43-1.77 (30-60% glass fiber); 1.34 (30% carbon fiber)	
Bulk density at 20°C	g cm^{-3}	0.6-0.8	
Refractive index, 20°C	-	1.581-1.586	
Haze	%	3.1	
Melting temperature, DSC	°C	234-240, 280 (30-60% glass fiber); 280 (30% carbon fiber)	

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PARAMETER	UNIT	VALUE	REFERENCES
Thermal expansion coefficient, 23-80°C	$^oC^{-1}$	5E-5; 1.4-1.8E-5	
Thermal conductivity, melt	W m^{-1} K^{-1}	0.38; 0.55 (50% glass fiber)	
Glass transition temperature	°C	75-85	
Specific heat capacity	J K^{-1} kg^{-1}	2510	
Heat of fusion	kJ mol^{-1}	37	
Heat deflection temperature at 0.45 MPa	°C	96; 237-238 (30-50% glass fiber)	
Heat deflection temperature at 1.8 MPa	°C	224-245 (30-50% glass fiber)	
Dielectric constant at 100 Hz/1 MHz	-	3.9-4.5 (30-60% glass fiber)	
Relative permittivity at 100 Hz	-	5	
Relative permittivity at 1 MHz	-	4-5	
Dissipation factor at 100 Hz	E-4	70 (30-50% glass fiber)	
Dissipation factor at 1 MHz	E-4	80-90 (30-50% glass fiber)	
Volume resistivity	ohm-m	2E13 (30-60% glass fiber)	
Surface resistivity	ohm	1E14	
Electric strength K20/P50, d=0.60.8 mm	kV mm^{-1}	24-31 (30-60% glass fiber)	
Comparative tracking index	V	>400 to 600 (30-60% glass fiber)	
Coefficient of friction	-	0.36-0.53	
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	99; 180-280 (30-60% glass fiber); 250 (30% carbon fiber)	
Tensile modulus	MPa	4,700-4,800; 11,500-24,000 (30-60% glass fiber)	
Elongation	%	1.5-2.3	
Tensile yield strain	%	1.8-2.0 (50-60% glass fiber); 1.3 (30% carbon fiber)	
Flexural strength	MPa	160; 280-400 (30-60% glass fiber)	
Flexural modulus	MPa	4,400; 11,000-21,000 (30-60% glass fiber); 2,300 (30% carbon fiber)	
Charpy impact strength, 23°C	kJ m^{-2}	35-72	
Charpy impact strength, notched, 23°C	kJ m^{-2}	6.3-11.8	
Izod impact strength, 23°C	J m^{-1}	460-850 (30-60% glass fiber); 450 (30% carbon fiber)	
Izod impact strength, notched, 23°C	J m^{-1}	20; 70-120 (30-60% glass fiber); 60 (30% carbon fiber)	
Poisson's ratio	-	0.35 (50% glass fiber)	
Rockwell hardness	-	M108	
Shrinkage	%	0.1-0.5 (30-60% glass fiber); 0.03-0.1 (30% carbon fiber)	
Melt volume flow rate (ISO 1133, procedure B), 275°C/2.16 kg	cm^3/10 min	3-31 (30-50% glass fiber)	
Melt index, 275°C/3.8 kg	g/10 min	6-41 (30-50% glass fiber)	
Water absorption, 24h at 23°C	%	0.10-0.20 (30-60% glass fiber); 0.22 (30% carbon fiber)	
Moisture absorption, equilibrium 23°C/50% RH	%	0.7-1.5	

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PARAMETER	UNIT	VALUE	REFERENCES
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	non-resistant	
Aliphatic hydrocarbons	-	excellent	
Aromatic hydrocarbons	-	excellent	
Esters	-	excellent	
Greases & oils	-	excellent	
Halogenated hydrocarbons	-	good	
Ketones	-	excellent	
Good solvent	-	m-cresol, formic acid, hexafluoroisopropanol, phenol/ethanol=4/1, sulfuric acid, trifluoroacetic acid	
Non-solvent	-	n-butanol, n-heptane, water	
FLAMMABILITY			
Ignition temperature	°C	331	
Autoignition temperature	°C	385	
Limiting oxygen index	% O_2	25 (30-60% glass fiber)	
UL 94 rating	-	HB	
TOXICITY			
NFPA: Health, Flammability, Reactivity rating	-	0/1/0	
Oral rat, LD_{50}	mg kg^{-1}	>5000	
PROCESSING			
Typical processing methods	-	injection molding	
Preprocess drying: temperature/ time/residual moisture	°C/h/%	80-120/3-12/0.3	
Processing temperature	°C	250-280 (injection molding); 255-265 (film casting)	
Processing pressure	MPa	20-150 (injection)	
Additives used in final products	-	lubricants, release agents, color master batches, blowing agents, UV stabilizers	
Applications	-	automotive (mirror housings, door handles, headlamp surrounds, cam covers and clutch parts); food and water contact; small appliances (shaver heads, electric iron parts, sewing machine components and vacuum cleaner motor supports); electronics (phone housings, induction motor supports, safety switches, DVD disk supports and internal moving parts); healthcare products resistant to γ radiation	
Outstanding properties	-	gas barrier properties, recyclability, rigidity, resistance to mechanical stresses	
BLENDS			
Suitable polymers	-	PA6, PET, PPTA	
ANALYSIS			
FTIR (wavenumber-assignment)	cm^{-1}/-	N-H – 3280, 1640, 1550; C-N – 1355, 1255	Seif, S; Cakmak, M, Polymer, 51, 3762-73, 2010.