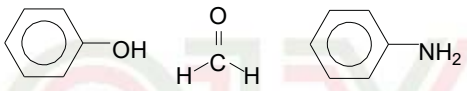
BZ polybenzoxazine

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	polybenzoxazine	Ghosh, N N; Kiskan, B; Yagci, Y, Prog. Polym. Sci., 32, 1344-91, 2007.
IUPAC name	-	3-phenyl-3,4-dihydro-2H-1,3-benzoxazine	
Acronym	-	BZ	
HISTORY			
Person to discover	-	Holly, F W; Cope, A C	Ghosh, N N; Kiskan, B; Yagci, Y, Prog. Polym. Sci., 32, 1344-91, 2007.
Date	-	1944	
Details	-	condensation reaction of primary amines with formaldehyde and phenol	
SYNTHESIS			Ghosh, N N; Kiskan, B; Yagci, Y, Prog. Polym. Sci., 1344-91, 2007.
Monomer(s) structure	-		
Monomer(s) CAS number(s)	-	108-95-2; 50-00-0; 62-53-3	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	94.11; 30.03; 93.13	
Method of synthesis	-	benzoxazine monomers are polymerized by solventless method; properties of polymer can be tailored by using monomers having different substitution groups which may provide different functionalities; polybenzoxazines are obtained using thermal or photoinitiated polymerization	Yagci, Y; Kiskan, B; Ghosh, N N, J. Polym. Sci., Part A; Polym. Chem., 47, 5565-76, 2009; Lu, H-C; Su, Y-C; Wang, C-F; Huang, C-F; Sheen, Y-C; Chang, F-C, Polymer, 49, 4852-60, 2008.
Temperature of polymerization	°C	101-110	Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Time of polymerization	h	0.16-6	Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Yield	%	77-87; 75-83	Takeichi, T; Kano, T; Aga, T, Polymer, 46, 12172-80, 2005; Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Mass average molecular weight, M_w	dalton, g/mol, amu	6,000-10,000	
STRUCTURE			
Crystallinity	%	0	Kim, W-K; Mattice, W L, Computational Theoretical Polym. Sci., 8, 3/4, 353-61, 1998.
COMMERCIAL POLYMERS			
Some manufacturers	-	Henkel, Huntsman	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	1.1-1.19	Parkpoom, L; Wongkasemjit, S; Chaisuwan, T, Mater. Sci. Eng. A, 527, 77-84, 2009.

PARAMETER	UNIT	VALUE	REFERENCES
Decomposition temperature	°C	310-350	Rajput, A B; Ghosh, N N, Intl. J. Polym. Mater., 60, 1, 27-39, 2010.
Glass transition temperature	°C	146-247; 170-340	Takeichi, T; Kano, T; Agag, T, Polymer, 46, 26, 12172-80, 2005; Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Maximum service temperature	°C	130-280	Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Long term service temperature	°C	150-180	
Hildebrand solubility parameter	$MPa^{0.5}$	16.98	Kim, W-K; Mattice, W L, Computational Theoretical Polym. Sci., 8, 3/4, 353-61, 1998.
Dielectric constant at 100 Hz/1 MHz	-	3.6/3.5	
Dissipation factor at 1 MHz	E-4	60-110	
Diffusion coefficient of water vapor	$cm^2\ s^{-1}\ x10^2$	3.6-4.9	
Contact angle of water, 20°C	degree	102-105; 139 (contains 0.05 silica)	Lu, H-C; Su, Y-C; Wang, C-F; Huang, C-F; Sheen, Y-C; Chang, F-C, Polymer, 49, 4852-60, 2008; Liu, J; Xin, Z; Zhou, C, Appl. Surf. Sci., 353, 1137-42, 2015.
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	100-125	Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Tensile modulus	MPa	2,000-5,300	
Elongation	%	1.6-4.1	
Flexural strength	MPa	132	
Flexural modulus	MPa	4,600	
Compressive strength	MPa	230; 5.2-12.4 (foam)	
Izod impact strength, notched, 23°C	$J\ m^{-1}$	18-31	
Shrinkage	%	0	Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Water absorption, equilibrium in water at 23°C	%	1.3-1.9	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	very good	
Alkalis	-	very good	
FLAMMABILITY			
Heat release	$W\ g^{-1}$	15 (peak)	
Char at 650°C	%	27-44; 28-34	Li, Y; Zhang, C; Zheng, Eur. Polym. J., in press 2011; Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.

PARAMETER	UNIT	VALUE	REFERENCES
PROCESSING			
Typical processing methods	-	casting	
Processing temperature	°C	200-218; 160-230 (curing temperature	Rimdusit, S; Tiptipakorn, S; Jubsilp, C; Takeichi, T, Reactive Functional Polym., 73, 369-80, 2013.
Process time	h	2-4	
Additives used in final products	-	Fillers: carbon fibers, clay, montmorillonite, titanium dioxide	
Applications	-	membranes, mold release agents in nanoimprint	
Outstanding properties	-	electrical performance, high glass transition temperature, near-zero shrinkage upon polymerization, very high char yield	
BLENDS			
Suitable polymers	-	BM, PC, PCL, PEO, PI, POSS, PU, PVP, SPI, epoxy, polyacrylate, polyester, rubber	