ST starch

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	starch	
ACS name	-	starch	
Acronym	-	ST	
CAS number	-	9005-25-8	
EC number	-	232-679-6	
RETECS number	-	GM5090000	
HISTORY			
Person to discover	-	Beccari, J	
Date	-	1745	
Details	-	Prof. Beccari separated wheat flour to starch and protein; starch grains were grounded on stone about 30,000 years ago in Europe. Egyptians are known to use wheat starch to stiffen cloth. Romans used it as thickening agent for sauces but also in cosmetics. Chinese used rice starch for smoothing paper.	
SYNTHESIS			
Monomer(s) structure	-	glucose	
Monomer(s) CAS number(s)	-	50-99-7	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	180.16	
Amylose contents	%	1-30; 20-30 (typical; non-modified); 50-80 (modified starch, e. g., amylomaize); 26 (corn); 22 (potato); 3 (modified potato); 25.5-30.9 (wheat)	Lotti, C L; Corradini, E; de Medeiros, E S; Mattoso, L H C, Antec, 3994-98, 2002; arocas, A; Sanz, T; Hernando, M I; Fiszman, S M, Food Hydrocolloids, 25, 1554-62, 2011.
Number average molecular weight, M_n	dalton, g/mol, amu	1,800,000 (amylopectin in potato)	Bertoft, E; Blennow, A, Adv. Potato Chem. Technol., 83-98, 2009.
Mass average molecular weight, M_w	dalton, g/mol, amu	10,000,000-100,000,000 (amylopectin); 10,000-1,000,000 (amylose); 200,000-3,900,000 (amylose in potato starch); 60,900,000 (amylopectin in potato); 260,000,000-700,000,000 (amylopectin in wheat); 280,000,000 (amylopectin in corn); 340,000,000 (amylopectin in rice)	Mischnick, P; Momcilovic, D, Adv. Carbohydrate Chem. Biochem., 64, 117-210, 2010; Bertoft, E; Blennow, A, Adv. Potato Chem. Technol., 83-98, 2009; Maningat, C C; Seib, P A; Bassi, S D; Woo, K S; Lasater, G D, Starch, 3rd Ed., 441-510, Elsevier, 2009.
Polydispersity, M_w/M_n	-	1.29-6.9 (amylose in potato)	Bertoft, E; Blennow, A, Adv. Potato Chem. Technol., 83-98, 2009.
Polymerization degree (number of monomer units)	-	840-21,800 (amylose in potato); 11,200 (amylopectin in potato); 1,000-5,000 (amylose in wheat); 10,000 (amylopectin in wheat); 4,700-15,000 (amylopectin from various sources)	Bertoft, E; Blennow, A, Adv. Potato Chem. Technol., 83-98, 2009; Maningat, C C; Seib, P A; Bassi, S D; Woo, K S; Lasater, G D, Starch, 3rd Ed., 441-510, Elsevier, 2009.
Molar volume at 298K	$cm^3 mol^{-1}$	97.5 (wheat)	Habeych, E; Guo, X; van Soest, J; van der Goot, A J; Boom, R, Carbohydrate Polym., 77, 703-12, 2009.
Radius of gyration	nm	104-217; 244.3 (amylopectin in potato); 78.4-88.6 (tacca starch)	Tan, H-Z; Li, Z-G; Tan, B, Food Res. Int., 42, 551-76, 2009; Bertoft, E; Blennow, A, Adv. Potato Chem. Technol., 83-98, 2009; Nwokocha, L M; Senan, C; Williams, P A, Carbohydrate Polym., in press, 2011.

PARAMETER	UNIT	VALUE	REFERENCES
STRUCTURE			
Crystallinity	%	25-45; 32-36 (wheat starch); 57.6 (amorphous content in native maize starch); 100 (amorphous content in processed maize starch)	Lotti, C L; Corradini, E; de Medeiros, E S; Mattoso, L H C, Antec, 3994-98, 2002; Du, X; MacNaughtan, B; Mitchell, J R, Food Chem., 127, 188-91, 2011.
Cell type (lattice)	-	monoclinic; hexagonal	Perez, S; Baldwin, P M; Gallant, D J, Starch, 3rd Ed., 149-192, Elsevier, 2009.
Cell dimensions	nm	a:b:c= 2.124:1.172:1.069 (B2); a:b:c= 1.85:1.85:1.04 (B)	Perez, S; Baldwin, P M; Gallant, D J, Starch, 3rd Ed., 149-192, Elsevier, 2009.
Unit cell angles	degree	γ=123.5	Perez, S; Baldwin, P M; Gallant, D J, Starch, 3rd Ed., 149-192, Elsevier, 2009.
Crystallite size	nm	7-10 (wheat)	Maningat, C C; Seib, P A; Bassi, S D; Woo, K S; Lasater, G D, Starch, 3rd Ed., 441-510, Elsevier, 2009.
Spacing between crystallites	nm	3.5-3.7 (amylopectin in potato)	Bertoft, E; Blennow, A, Adv. Potato Chem. Technol., 83-98, 2009.
Polymorphs	-	A, B, V, I, II	Biliaderis, C G; Starch, 3rd Ed., 293-372, Elsevier, 2009.
Chain conformation	-	double helix (both amylose and amylopectin); diameter of 1 nm	Momany, F A; Willett, Antec, 1999.
Lamellae thickness	nm	5.3-5.8 (amylopectin in potato)	Bertoft, E; Blennow, A, Adv. Potato Chem. Technol., 83-98, 2009.
Avrami constants, k/n	-	k=0.14-0.54 and n=0.47-0.96 (rice)	Hu, X; Xu, X; Jin, Z; Tian, Y; Bai, Y; Xie, Z, J. Food Eng., 106, 262-66, 2011.
COMMERCIAL POLYMERS			
Some manufacturers	-	BIOP, Novamont	
Trade names	-	Biopar	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	1.34-1.65	
Color	-	white	
Birefringence	-	1.0131, 0.0139	
Odor	-	odorless	
Melting temperature, DSC	°C	decomposition; 240-250 (estimated above degradation temperature)	
Gelatinization temperature	°C	58-78	Biliaderis, C G; Starch, 3rd Ed., 293-372, Elsevier, 2009.
Glass transition temperature	°C	-55 and 27-43 (two transitions)	Lotti, C L; Corradini, E; de Medeiros, E S; Mattoso, L H C, Antec, 3994-98, 2002.
Enthalpy of gelatinization	J g^{-1}	0.9-4.2 (wheat)	Maningat, C C; Seib, P A; Bassi, S D; Woo, K S; Lasater, G D, Starch, 3rd Ed., 441-510, Elsevier, 2009.
Surface tension	mN m^{-1}	39	
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	1.6-2.1	
Tensile modulus	MPa	1,020-1,140	
Tensile stress at yield	MPa	1.4-22	
Elongation	%	27-84	

ST starch

PARAMETER	UNIT	VALUE	REFERENCES
Tensile yield strain	%	3-104	
Elastic modulus	MPa	9-38.7	
Intrinsic viscosity, 25°C	$dl\ g^{-1}$	118-384 (amylose); 116-171 (amylopectin)	
Water absorption, equilibrium in water at 23°C	%	22.5	
Moisture absorption, equilibrium 23°C/50% RH	%	10.2-13.3	
CHEMICAL RESISTANCE			
Good solvent	-	liquid ammonium	
Non-solvent	-	alkalies, diethyl ether	
FLAMMABILITY			
Ignition temperature	°C	>93.3	
Autoignition temperature	°C	>400	
WEATHER STABILITY			
Spectral sensitivity	nm	644-662 (amylose, maximum absorption); 531-575 (amylopectin, maximum absorption)	
BIODEGRADATION			
Typical biodegradants	-	enzymolysis; biodegradation in composter	Jayasekara, R; Sheridan, S; Lourbakos, E; Beh, H; Christi, G B Y; Jenkins, M; Halley, P B; McGlashan, S; Lonergan, G T, Int. Biodeter. Biodeg., 51, 77-81, 2003.
TOXICITY			
NFPA: Health, Flammability, Reactivity rating	-	1/1/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
Mutagenic effect	-	not known	
Teratogenic effect	-	not known	
Reproductive toxicity	-	not known	
TLV, ACGIH	$mg\ m^{-3}$	10	
OSHA	$mg\ m^{-3}$	5 (respirable), 15 (total)	
Oral rat, LD_{50}	$mg\ kg^{-1}$	>5,000	
Skin rabbit, LD_{50}	$mg\ kg^{-1}$	>2,000	
ENVIRONMENTAL IMPACT			
Toxic products of degradation	-		
Biological oxygen demand, BOD_5	$mg\ l^{-1}$	1,100-3,900	
Chemical oxygen demand	$mg\ l^{-1}$	4,200-7,000	
PROCESSING			
Typical processing methods	-	extrusion, injection molding	
Processing temperature	°C	160 (extrusion); 180 (melt, injection)	
Processing pressure	MPa	5 (injection and holding)	

PARAMETER	UNIT	VALUE	REFERENCES
Additives used in final products	-	Plasticizers: diethylene glycol dibenzoate, dipropylene glycol dibenzoate, glycerin, glycerol esters, polyethylene and polypropylene glycols, sorbitol, soybean oil, succinate polyester, sunflower oil, triacetin, tributyl acetyl citrate, vegetable oil; Antistatics: dicoconut alkyl dimethyl ammonium methyl sulfate, graft polymerized starch, polymeric systems based on polyamide/polyether block amides; Release: magnesium stearate, polymethylhydrogensiloxane, potassium stearate, starch ester	
Applications	-	biodegradable plastics	
Outstanding properties	-	sustainable, biodegradable	
BLENDS			
Suitable polymers	-	CA, chitosan, HDPE, LPDE, PCL, PEO, PLA, PR, PVOH	
ANALYSIS			
FTIR (wavenumber-assignment)	cm^{-1}/-	starch conformation – 1045, 1022; COH – 1080, 1047, 1022, 995, 928; COC – 860	Wei, C; Qin, F; Zhou, W; Xu, B; Chen, C; Chen, Y; Wang, Y; Gu, M; Liu, Q, Food Chem., 128, 645-52, 2011; Mutungi, C; Onyango, C; Doert, T; Paasch, S; Thiele, S; Machill, S; Jaros, D; Rohm, H, Food Hydrocolloids, 25, 477-85, 2011.
Raman (wavenumber-assignment)	cm^{-1}/-	confocal Raman imaging	Wetzel, D L; Shi, Y-C; Schmidt, U, Vibrational Spect., 53, 173-77, 2010.
NMR (chemical shifts)	ppm	high-resolution solid-state NMR records characteristic spectra of ordered helices; C NMR permits determination of double helix contents	Lin, J-H; Singh, H; Wen, C-Y; Chang, Y-H, Cereal Sci., in press, 2011.
x-ray diffraction peaks	degree	15, 17, 18, 23 (A polymorph); 5, 17, 22, 24 (B polymorph)	Maningat, C C; Seib, P A; Bassi, S D; Woo, K S; Lasater, G D, Starch, 3rd Ed., 441-510, Elsevier, 2009.