Table SI: Methods reported to synthesize lignin nano- and microparticles.

Lignin Source	Preparation	Morphology	Application	Ref.
Wheat straw and eucalyptus wood chips	*In situ* via ethanolic pulping	Precipitate in fiber walls, 1 µm	—	54
Wood chips	Simultaneous saccharification and fermentation	*In situ* particle formation, 5–10 µm	—	22
Alkalin lignin	Acid precipitation	182 nm	pH responsiviness, pickering emulsions	36
	Acetylation, antisolvent self-assembly	80 nm	—	32
	Suspension polymerization	Macroporous, 800 ± 100 µm	—	57
	Grafting diazonium salt and self-assembly by hydrophobic interactions	~100 nm, hollow spherical structures	—	45
	Freeze drying	Sheet-like morphology	Free-radical scavenger, filler composites	53
Low-sulfonated lignin	Precipitation at different pH (ethylene glycol optionally present)	—	—	33
Kraft lignin	Inverse suspension polymerization	Beads	—	55
	Antisolvent precipitation	300–600 nm, PDI 0.15–0.56	—	34
	Compressed CO_2 antisolvent	Quasi-spherical nanoparticles, mesopores, 38 nm	High UV absorption (dispersion stability, enhanced solubility)	59
	Polymer-grafting on lignin	7–100 nm	Hydrophilicity/hydrophobicity, pickering emulsions	44
	Acid precipitation	—	—	61
Sulfate lignin	Aggregation at low concentration (10 mg/l) of aqueous dispersions	30–200 nm, polydisperse	—	60
Black liquor	Enzymatic saccharification and physical comminution	170–260 nm, PDI 0.155	—	50
	Acid precipitation from alkali solution	100 µm	Filler (polystyrene films)	37
	Acid precipitation	30–3500 nm	Removal of KL from wastewaters, aggregative stability	38
	CO_2 gas-induced precipitation	Loosely bound irregular, 1–11 µm	—	39
	Mechanical homogenization	Irregular shapes, 10–50 nm	Filler composites	41
Kraft lignin, organosolv lignin	Flash precipitation of dissolved lignin	Spheroidal particles, 45–250 nm (rough surface)	—	49
Kraft lignin, organosolv lignin, alkali lignin	Aerosol flow	Spherical particles, 30 nm–2 µm	Amphiphilicity, pickering emulsions	52
Hardwood dioxane lignin, softwood kraft lignin	Nanoprecipitation by addition of water to acetone and water co-solution	Spherical, 80–104 nm	Antioxidant and UV protectant	58
Commercial lignin	Supernatant phase generated from the epoxidation reaction	15 nm–500 µm	Wood resistance to biodegradation	43
Synthetic lignin	Deposition of droplets on mica with heteroxylans	—	—	51
Residue from bioethanol production	Precipitation from an ethylene glycol solution	Clustered structures, 49 ± 16 nm	Antioxidant and antibacterial activity, filler in PLA/g-PLA, composites (good stability at various pH)	46–48
Wheat straw, Sarkanda grass, commercial product	Hydroxymethylation or epoxylated precipitation from an ammonium solution	100–800 nm, 50–500 nm, ~250 nm	Biocidal properties	56
Wheat straw, Sarkanda grass lignin	Ultrasonic irradiation of lignin in aqueous suspension	10–50 nm, PDI 4.4–10.7 (rough surface)	—	40
Sarkanda grass lignin	Hydroxymethylation	70–700 nm	—	42

Note: PDI, polydispersity index; UV, ultraviolet; KL, kraft lignin; PLA, polylactic acid; g-PLA, glycidyl methacrylate-g-polylactic acid.