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Silver Nanomaterials: Synthesis and (Electro/Photo) Catalytic Applications

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3. Synthetic Strategies

3.1 Basic Principles of Ag Nanomaterial Synthesis

3.1.1. Chemical Reduction Method

Table S1. Comprehensive literature reports for fabricating well-defined Ag NPs.

S. No.	Method	Solvent	Precursor	Reducing agent	Stabilizer	Conditions	Product Description	Ref.
1.	Wet-chemical	*N, N*-dimethyl formamide	$AgNO_3$	*N, N*-dimethyl formamide (DMF)	Poly-(vinylpyrrolidone) (PVP)	Heated at reflux for 45 min	Flat nanoprisms of 30 nm in thickness and lateral dimension of around 200 nm	1
2.	Wet-chemical	Water	$AgNO_3$	Sodium citrate	Sodium citrate	Heated at 100 °C for 1 h in the presence of NaOH (final solution having pH = 7.0-7.1)	Ag nanowires ranging from 166 nm to 12 microns in length along with average width of 35 ± 6 nm	2

3.	Wet-chemical	Water	$AgNO_3$	Sodium borohydride	Glutathione	Temperature maintained in the range from 0 to 50 °C	Hollow Ag NPs with outer diameters ranging from 20 to 40 nm and shell thickness of 7.3 ± 1.5 nm	[3]
4.	Wet-chemical	Water	$AgNO_3$	Sodium borohydride	Poly(*N*-vinyl pyrrolidone) and sodium citrate	Stirring at room temperature (r.t.) for 30 min in the presence of H_2O_2	Ag nanoprisms of 30-300 nm in edge length and 3–9 nm in thickness	[4]
5.	Wet-chemical	Aqueous poly(methacrylic acid) (PMAA)	$AgNO_3$	Ascorbic acid	Poly(methacrylic acid) (PMAA)	Solution kept static at r.t. for 24 h (low pH around 2 after the addition of HNO_3 is necessary for favoring preferential growth of nanowires)	Ag nanowires of around 30-40 nm in diameter	[5]
6.	Wet-chemical	Water	$AgNO_3$	Hydroquinone	Tetramethylammonium hydroxide (TMA(OH)), ammonia (NH_3) and ammonium chloride (NH_4Cl)	Room temperature (r.t)	Ag NPs with spherical and prolate morphology in the size ranging from 5 to 60 nm	[6]
7.	Wet-chemical	Water	$AgNO_3$	Glucose	Poly(*N*-vinyl pyrrolidone)	Stirred at 90 °C for 3000 min	Spherical and trigonal NPs with diameters of 65 nm and an edge length of 140 nm, respectively	[7]
8.	Wet-chemical	Water	$AgNO_3$	Glucose, fructose, lactose and sucrose	Poly(vinyl pyrrolidone) (PVP) and gelatin	Stirred at 55-60 °C for 1 h at the pH between 8.5 to 9.0	Spherical Ag NPs with the average size of 35 nm	[8]
9.	Wet-chemical	Water	$AgNO_3$	*β*-D-glucose	Polyethylene glycol (PEG)	Stirring in dark at 45 °C for different time periods up to 48 h	Spherical NPs of around 10 to 25 nm	[9]
10.	Wet-chemical	DMF	$AgNO_3$	DMF	Poly(vinyl pyrrolidone) (PVP)	Kept in autoclave, heated from 140 to 180 °C for 1-16 h	Ag NPs possessing various morphologies ranging from nanorods, nanocubes, triangular, hexagonal and enneahedral nanoplates, to polyhedrons were formed having dimensions ranging from 10 to 150 nm	[10]
11.	Wet-chemical	Water	$AgNO_3$	Hydrazine dihydrochloride	-	-	Spherical Ag NPs of 40 to 70 nm in diameter	[11]
12.	Wet-chemical		$AgNO_3$	Sodium citrate and sodium borohydride	Poly(vinyl pyrrolidone) (PVP)	Different samples prepared by stirring at boiling, ice-cold and r.t. in light and dark conditions (boiling temperature in case of sodium citrate and r.t. in case of $NaBH_4$)	Spherical and triangular shaped NPs in sizes ranging from 30 to 200 nm	[12]

13.	Wet-chemical	Water	$AgNO_3$	Poly(vinyl pyrrolidone) (PVP)	Poly(vinyl pyrrolidone) (PVP)	Stirred at 60 °C for 21 h in air	Nanoplates of Ag between 50 and 350 nm	[13]
14.	Wet-chemical	Water	$AgNO_3$	Sodium citrate and tannic acid	Poly(vinyl pyrrolidone) (PVP)	Heated at 90 °C	Spherical Ag NPs of 10–200 nm	[14]
15.	Wet-chemical	Water	Silver perchlorate	Sodium borohydride	Sodium borohydride	Temperature maintained at 5 °C using an ice bath for different time periods i.e. from 1 min to 60 min	Small sized Ag NPs of 5–8 nm in diameter	[15]
16.	Wet-chemical	Water	Silver perchlorate	Sodium borohydride	-	Stirred at r.t.	Ag NPs having radii of 4–8 nm	[16]
17.	Wet-chemical	Ethylene glycol	$AgNO_3$	Ethylene glycol	Polyvinyl pyrrolidone (PVP)	Solution stirred at 160 °C for 1 h	Ag nanowires of 30–60 nm in diameter and 1–50 μm in length	[17]
18.	Wet-chemical	Ethylene glycol	$AgNO_3$	Ethylene glycol	Polyvinyl pyrrolidone (PVP)	Solution refluxed at 160 °C for 60 min	Bicrystalline Ag nanowires having diameters of 30–50 nm and length up to 50 μm	[18]
19.	Wet-chemical	Water	$AgNO_3$	Formaldehyde and sorbitol	-	Solution sonicated for 30 min in the presence of NaOH as activator	Quasi spherical and irregular shaped Ag NPs with diameters between 20 and 50 nm	[19]
20.	Wet-chemical	Water	Ammoniacal silver hydroxide $[Ag(NH_3)_2]OH$	Glucose	n-hexadecyltrimethylammonium bromide (HTAB)	Heated in an autoclave at 120 °C for 8 h	Ag nanocubes with an edge length of 55 ± 5 nm	[20]
21.	Sonochemical	Water	$AgNO_3$	-	-	Sonicated for 1 h in atmosphere of argon-hydrogen at temperature of 10 °C	Ag NPs of around 20 nm in size	[21]
22.	Sonochemical	DMF	$AgNO_3$	DMF	Polyvinyl pyrrolidone (PVP)	Sonicated for 30 min under ambient reaction conditions	Ag nanoplates with average sizes of 120 ± 10 nm	[22]
23.	Sonochemical	Water	$AgNO_3$	L-ascorbic acid (AA)	-	Sonicated for 4 min using an ultrasonicator having power of 100 W and frequency of 28 kHz	Ag microflowers with average sizes of 1.3μm	[23]
24.	Sonochemical	Water	$AgNO_3$ and $Ag(S_2O_3)_2^{3-}$	KBH_4	Polydichloroethylene (PDCE) and dibutyl-β-naphthalin sulfonate (DPS)	Sonicated for 10 min	Ag NPs with average diameters of 2 nm (using $AgNO_3$) and 8.5 nm (using $Ag(S_2O_3)_2^{3-}$)	[24]
25.	Sonochemical	Water	$AgNO_3$	Methenamine (HMTA)	Polyvinyl pyrrolidone (PVP)	Ultrasonicated for 1 h	Ag nanorods with mean diameters of 100 nm and length of 4–7 μm	[25]
26.	Sonochemical	Water	$AgNO_3$	Polymethylacrylic acid (PMAA) and ultrasonic irradiation	Polymethylacrylic acid (PMAA)	Solution having pH = 4.5 sparged using argon for 2 h and sonicated for 3 h at 20 °C under argon flow	Ag nanoclusters approximately 2 nm in diameter	[26]

27.	Microwave	Water	$AgNO_3$	Alkaline 2,7-dihydroxy naphthalene (2,7-DHN)	Polyoxyethylene isooctyl phenyl ether (TX-100)	Microwave heating for 1 min	Ag NPs in sizes ranging from 4 to 35 nm	[27]
28.	Microwave	Water	$AgNO_3$	L-lysine or L-arginine	Starch	Microwave heating at 150 °C for 10 s under magnetic stirring	Ag NPs having mean diameters of 26.3 nm	[28]
29.	Microwave	Ethylene glycol	$AgNO_3$	Ethylene glycol	Polyvinylpyrrolidone	Microwave heating at 300 W for 3.5 min	Ag nanowires of length 4-12 μm and diameter of around 45.2 ± 4.2 nm	[29]
30.	Microwave	Water	$AgNO_3$	Polyethylene glycol	Polyethylene glycol	Microwave irradiation at 100 °C for 60 min	Ag nanorods of 50–200 nm in thickness and length of several microns	[30]
31.	Microwave	Water	$AgNO_3$	*β*-D-glucose, sucrose and maltose	Polyvinylpyrrolidone	Microwave irradiation for 30–60 s	Ag NPs with average sizes of 3.43, 5.03 and 15.2 nm in the case of glucose, maltose and sucrose respectively	[31]
32.	Microwave	Water	$AgNO_3$	Glutathione	Glutathione	Microwave irradiations by microwave having power of 50 W for 30-60 s	Ag NPs of 5–10 nm	[32]
33.	Microwave	Water	$AgNO_3$	Monoethanolamine (MEA)	Polyacrylic acid (PAA)	Microwave irradiation 700 W for 60 s	Spherical Ag NPs with sizes smaller than 20 nm	[33]
34.	Microwave	Water	$AgNO_3$	Carboxymethylated gum kondagogu (CMGK)	Carboxymethylated gum kondagogu (CMGK)	Microwave irradiation from microwave operating at power of 750 W for 50-90 s	Spherical Ag NPs with sizes of 9 ± 2 nm	[34]
35.	Microwave	Ethylene glycol	$AgNO_3$	Ethylene glycol	Poly(*N*-vinyl)pyrrolidone	Microwave heating at 140 °C	Ag NPs	[35]
36.	Microwave	Water	$AgNO_3$	Orange peel extract	Orange peel extract	Microwave irradiation at 90 °C for 15 min	Spherical Ag NPs with diameters ranging from 1 nm to 56.1 nm	[36]
37.	Microwave	Ethylene glycol	$AgNO_3$	Ethylene glycol	Polyacrylic acid (PAA)	Microwave heating at 200 °C for 15 min	Ultra-small Ag NPs with radii of 3 nm	[37]
38.	Microwave	Choline chloride and glycerol	$AgNO_3$	Oleylamine (OAm)	Oleylamine (OAm)	Microwave heating at 100 °C for 30 s	Spherical Ag NPs with average sizes of 10.1 ± 4.7 nm	[38]
39.	Greener Biosynthesis	Water	$AgNO_3$	Polyphenols present in tea and coffee extract	Polyphenols present in tea and coffee extract	Shaken at room temperature for 2 h	Spherical Ag NPs with sizes ranging between 5 and 100 nm	[39]
40.	Greener Biosynthesis	Water	$AgNO_3$	Cell extract of *Chlorella pyrenoidosa* (algae)	Cell extract of *Chlorella pyrenoidosa* (algae)	Solution incubated at 28 ± 2 °C for 24 h	Ag NPs with sizes between 2 and 15 nm	[40]
41.	Greener Biosynthesis	Water	$AgNO_3$	*β*-D-glucose	Starch	Solution purged with argon and heated at 40 °C for 20 h	Ag NPs with sizes from 1 to 8 nm	[41]

42.	Greener Biosynthesis	Water	$AgNO_3$	Living alfalfa plant	Living alfalfa plant		Ag NPs with sizes between 2 and 4 nm	[42]
43.	Greener Biosynthesis	Water	$AgNO_3$	Ascorbic acid present in aqueous extract of Sapodilla (*Manilkara zapota*) fruit	Ascorbic acid	Solution stirred at 60 ^oC for 30 min	Spherical Ag NPs with sizes between 40 and 70 nm	[43]
44.	Greener Biosynthesis	Water	$AgNO_3$	Aloe Vera leaf extract	Aloe Vera leaf extract	Incubated in dark for overnight at room temperature	Ag NPs with sizes between 5 and 85 nm	[44]
45.	Greener Biosynthesis	Water	$AgNO_3$	Leaf extract and infusion of roots of *Althaea officinalis* plant	Leaf extract and infusion of roots of *Althaea officinalis* plant	Stirred in dark for 24 h	Ag NPs formed from leaf extract and infusion of roots were found to be 157 ± 11 nm and 293 ± 12 nm in size, respectively	[45]
46.	Greener Biosynthesis	DMSO	Ag_2O	Alkali lignin	Alkali lignin	Solution stirred at room temperature for 12 h	Spherical Ag NPs with sizes between 17 and 27 nm	[46]
47.	Greener Biosynthesis	Water	$AgNO_3$	Cell-free extract of Pseudomonas aeruginosa isolated from mangrove	Flavonoids present in extract	Solution stirred at 100 ^oC for 2 h (conventional thermal treatment) Microwave irradiation operated at 900 W with 15 repetitive cycles	Spherical Ag NPs with average sizes of 14.6 ± 1 nm	[47]
48.	Greener Biosynthesis	Water	$AgNO_3$	Phytochemical spresent in leaf extract of *Alysicarpus monilifer*	Phytochemicalspresent in leaf extract of *Alysicarpus monilifer*	Solution stirred for 1 h	Spherical Ag NPs with mean sizes of 15 ± 2 nm	[48]
49.	Greener Biosynthesis	Water	$AgNO_3$	Phenolic compounds, anti-oxidants, anthocyanins, flavonoids and tannins present in blackberry, blueberry, pomegranate, green tea and turmeric extracts	Phenolic compounds, anti-oxidants, anthocyanins, flavonoids and tannins present in blackberry, blueberry, pomegranate, green tea and turmeric extracts	Solution stirred overnight at room temperature	Spherical and triangular Ag NPs with sizes ranging from 5 to 200 nm	[49]
50.	Greener Biosynthesis	Water	$AgNO_3$	Phytochemical spresent in aqueous extract of *Salacia chinensis* (SC) bark	Phytochemicalspresent in aqueous extract of *Salacia chinensis* (SC) bark	Stirred at room temperature for 4 h	Spherical Ag NPs with sizes between 40 and 80 nm	[50]
51.	Thermal decomposition	-	Silver (I) salicylate [Ag(HSal)	-	-	Sample loaded in tubular furnace in Ar atmosphere and	Ag NPs with average size between 40 and 50 nm	[51]

			] prepared from $AgNO_3$			heated at 400 °C for 3h		
52.	Thermal decomposition	-	Silver acetate	-	-	Sample was heated in flowing dry N_2 and N_2–H_2O gas from 323 to 773 K	Ag NPs with sizes in the range from 15 to 24 nm	[52]
53.	Thermal decomposition	Water	$AgNO_3$	-	Polyvinylpyrrolidone (PVP)	Calcination from 400 to 800 °C with flow rate of 50 mL/min initially in O_2 and then in N_2 atmosphere	Calcination temperature from 400 to 800 °C resulted in the formation of Ag NPs with sizes ranging from 7.88 to 3.29 nm	[53]
54.	Thermal decomposition	-	$AgNO_3$	Polyphenols present in cochineal dye and pomegranate peel extract	Polyphenols present in cochineal dye and pomegranate peel extract	Masses of cochineal dye and pomegranate peel mixed with $AgNO_3$ were grounded and heated in a furnace up to 600 °C for 3 h.	Ag NPs with sizes of 15–50 nm.	[54]
55.	Continuous flow	Isoamyl ether	Silver pentafluoropropionate	-	Trioctylamine (TOA)	Reaction conducted in a tubular microreactor heated and stirred at temperature 100 and 140 °C with flow rate varying between 0.08 mL min^{-1} and 0.7 mL min^{-1}	Ag NPs with sizes between 3 and 12 nm	[55]
56.	Continuous flow	Water and KOH	$AgNO_3$	Oleic acid sophorolipid (OASL) and stearic acid sophorolipid (SASL)	Oleic acid sophorolipid (OASL) and stearic acid sophorolipid (SASL)	Temperature of reactor maintained at 90 °C with flow rates of 35 mL min^{-1} and 100 mL min^{-1} with residence time of 300 s and 105 s	Diverse sized Ag NPs formed	[56]
57.	Continuous flow	Water	$AgNO_3$	Cinnamomum camphora leaf extract	Polyols present in Cinnamomum camphora leaf extract	Microreactor heated in glycerin bath at 60 and 90 °C	Silver nanostructures of various shapes such as rods, spheres and wire formed	[57]
58.	Continuous flow	Water	$AgNO_3$	Sodium citrate	Sodium citrate and n-butanol	Flow rate from 6-12 mL min^{-1}at 90 °C	Ag NPs with sizes from 1 nm to70 nm	[58]
59.	Continuous Microwave flow	Ethanol, ethylene glycol, water	$AgNO_3$	Ethylene glycol	PVA, PVP, linoleic acid and sodium linoleate	Con-flow microwave reactor operated for 60 min	Ag NPs of 3–30 nm	[59]
60.	Continuous Microwave flow	Water	Diamine silver (I) complex $[Ag(NH_3)_2]^+$	Carboxymethylcellulose (CMC)	Carboxymethylcellulose (CMC)	Solution temperature at 100 °C using microwave irradiation	Ag NPs of 1–3 nm	[60]
61.	Continuous Microwave flow	Ethylene glycol	$AgNO_3$ and AgOAc	Ethylene glycol	Polyvinylpyrolidone (PVP)	Microwave reactor with flow rates of 0.635 to 2.5 dm^3/h for 3–24 s and exit	Ag NPs with sizes in the range from 10 nm to 160 nm were obtained	[61]

						temperature of 170 °C for $AgNO_3$ and 150 °C for AgOAc		

3.2 Supported Ag-~~Based~~ based NPs

Table S2. Reported procedures for the synthesis of supported Ag NPs.

S. No.	Types of support	Support materials	Method	Solvent	Precursor	Reducing agent	Stabilizer	Condition	Product description	Ref.
1.	Carbon	Carbon nanofibers	Wet-chemical reduction	Water	$Ag(NH_3)_2OH$	Glucose	-	Heated in autoclave at 180 °C for 3 h	Ag NPs with sizes between 25 and 50 nm	62
2.	Carbon	Carbon	Wet-chemical reduction	Water	$AgNO_3$	Glycerol	-	Stirred at r.t. for 24 h	Spherical Ag NPs with sizes of around 20 nm	63
3.	Carbon	Activated carbon	Wet-chemical reduction	Cyclohexane	Ag–oleate complex (synthesized using $AgNO_3$ and potassium oleate)	Oleic acid	Dodecylamine	Stirred at r.t. for 24 h	Ag NPs with sizes of 4 nm	64
4.	Carbon	Carbon	Wet-chemical reduction	Oleylamine	Silver acetate	-	-	Stirred in N_2 atmosphere at 30 °C	Ag NPs with sizes in the range from 2 to 9 nm	65
5.	Carbon	Mesoporous Carbon produced from wood	Green	Water	$Ag(NH_3)_2NO_3$ (prepared from $AgNO_3$ and ammonia)	Functional groups present in natural wood (Lignin)	Functional groups present in natural wood (Lignin)	Carbonized at 800 °C in N_2 atmosphere for 2 h	Ag NPs with sizes between 10 and 16 nm	66
6.	Carbon	Carbon particles	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	Sodium citrate	Stirred for 12 h at r.t.	Ag NPs with mean particle sizes of 15 nm	67
7.	Carbon	Carbon microspheres (formed from *Brassica oleracea* pollen grains)	Green	Water	$AgNO_3$	Active groups in *Brassica oleracea* pollen grains	-	Calcination in air at 300 °C for 6 h followed by carbonization at 600 °C in N_2 atmosphere for 6 h	Crystalline Ag NPs with sizes between 50 and 100 nm	68
8.	Carbon	Graphene (Carboxylic sodium group	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	-	Stirred at r.t. for 1 h	Dispersed Ag NPs with diameters of	69

		functionalized)							6–20 nm on graphene	
9.	Carbon	Graphene	Wet-chemical reduction	Water	$[Ag(NH_3)_2]OH$ (formed from $AgNO_3$ and ammonia)	Formaldehyde	Poly(*N*-vinyl-2-pyrrolidone) (PVP)	Stirred at 60 °C for 7 min	Spherical Ag NPs	70
10.	Carbon	Graphene Oxide	Wet-chemical reduction	Water	$AgNO_3$	Hydroquinone	Sodium citrate	Mixture kept undisturbed for 75 min at r.t.	Spherical Ag NPs with average sizes of 80 nm	71
11.	Carbon	Graphene Oxide	Solid state chemical reaction	-	Silver acetate	Ascorbic acid	Polyethylene glycol (PEG)	Mixture grinded in a mortar for 30 min at r.t.	Irregular shaped spherical Ag NPs with sizes between 50 and 200 nm	72
12.	Carbon	Graphene Oxide	Sonochemical	Water	$AgNO_3$	$NaBH_4$	Sodium citrate	Mixture initially sonicated for 2 min and then kept at r.t. for 12 h	Uniformly distributed Ag NPs of nanometric dimension	73
13.	Carbon	Graphene Oxide	Photochemical	Water	$[Ag(NH_3)_2]OH$	-	-	Mixture was exposed to 450 W Hg lamp under constant stirring for 10 min	Dispersed Ag NPs on graphene oxide	74
14.	Carbon	Graphene Oxide	Wet-chemical reduction	Water	$AgNO_3$	Glucose	Starch	Mixture heated at 80 °C under constant stirring for 4 h	Ag NPs with mean diameters of 22 nm	75
15.	Carbon	Graphene Oxide	Wet-chemical reduction	Water	$AgNO_3$	Functional groups present in dopamine of GO-dopamine hybrid	Functional groups present in dopamine of GO-dopamine hybrid	Mixture stirred at r.t. for 3 h	Ag NPs with average sizes of 7.71 ± 1.34 nm	76
16.	Carbon	Reduced GO	Sonochemical	Water	$[Ag(NH_3)_2]OH$	-	-	Mixture ultrasonicated for 5, 15, 30 min with temperature of approximately 65, 75 and 80 °C respectively	Ag NPs with mean sizes varying from 4 to 13 nm formed	77
17.	Carbon	Graphene Oxide	Wet-chemical reduction	Water	$AgNO_3$	DMF	-	Mixture stirred at 60 °C for 6 h	Ag NPs of nanometric	78

									dimensions were formed	
18.	Carbon	Reduced GO	Wet-chemical reduction	Toluene	CH_3COOAg	Toluene solution of tetrabutylammonium borohydride (TBAB)	-	Mixture heated at 70–80 °C for 2 h	Ag NPs with average sizes of 5 nm	[79]
19.	Carbon	Graphene oxide nanosheets	Wet-chemical reduction	Water	$[Ag(NH_3)_2]OH$	Glucose	-	Mixture kept undisturbed at r.t. for 90 min	-	[80]
20.	Carbon	Carbon nanotubes	Wet-chemical reduction	DMF	$AgNO_3$	DMF	-	Solution with pH=6 (using HNO_3) was first heated at 60–62 °C with the addition of $AgNO_3$ solution for 1 h and then stirred at r.t. for 48 h	Ag NPs with average sizes of 34 nm	[81]
21.	Carbon	Carbon nanotubes	Impregnation method	Water	$AgNO_3$	-	-	Stirred at r.t. for 10 h, dried at 383 K and then calcined in air at 523 K for 4 h	Ag NPs with crystallite sizes from 4 to 18 nm	[82]
22.	Carbon	Carbon nanotubes	Wet-chemical reduction	Methanol-water	$AgNO_3$	-	-	Solution sonicated for 5 min and left at r.t. for 10-12 h	Ag NPs with average sizes of 22.6 ± 0.5 nm	[83]
23.	Carbon	Carbon nanotubes	Incipient wetness impregnation followed by (a)electron assisted reduction and (b) thermal calcination	Water	$AgNO_3$	-	-	Solution impregnated for 12 h, dried and (a) underwent plasma treatment for 1 h (b) thermally decomposed at 400 °C for 3 h in N_2	Ag NPs of 3.8 nm(in electron assisted reduction) and 25.5 nm in thermal calcination	[84]
24.	Carbon	Carbon nitride	Sonochemical	Water	$AgNO_3$	-	-	Solution ultrasonicated at 35 °C for 150 min having 28 kHz frequency	Spherical Ag NPs of 2–10 nm	[85]
25.	Carbon	Carbon nitride	Microwave	Water	$AgNO_3$	Sodium citrate	-	Solution stirred for 1 h and then heated in microwave at 80 °C for 30 min	Ag NPs with average sizes of 23.4 nm	[86]

26.	Carbon	Carbon nitride	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	-	Solution first stirred for 2 h after which cold $NaBH_4$ was added at 10 ^oC	Spherical Ag NPs with sizes ranging between 6 and 12 nm	87
27.	Carbon	Diamond films	Microwave plasma enhanced chemical vapor deposition and electron beam metal evaporation	-	-	-	-	After 1st diamond layer grown for 2 h, transferred to electron beam metal evaporator and 100 nm Ag NPs are embedded/ deposited at the rate of 1 Å/s	Ag NPs having diameters less than 100 nm	88
28.	Carbon	Diamond	Wet-chemical reduction	Ethylene glycol	$AgNO_3$	Ethylene glycol	-	Solution heated at 85 ^oC for 4 h under constant stirring	Ag NPs of sizes between 3 and 10 nm	89
29.	Silica	Silica	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	-	Stirred for 15 min	Ag NPs	90
30.	Silica	Silica	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	Starch	Solution stirred for 24 h at r.t., then dried at 110 ^oC for 4 h and finally calcined at 400 ^oC for 4 h	With different wt % Ag loadings, NPs within the range of 2–51 nm formed	91
31.	Silica	Silica	Incipient-wetness impregnation	Water	$AgNO_3$ and Silver 2-[2-(2-methoxyethoxy)ethoxy] Acetate [$AgO_2C(CH_2OCH_2)_3H$]	H_2	-	Material first dried in air and then in oven at 80 ^oC for 2 h and finally calcined at 500 ^oC for 2 h in air followed by reduction in H_2 at 330 ^oC for 2 h	Ag NPs with mean diameters of 4.5 ± 3.4 nm (nitrate precursor) and 7.7 ± 3.4 nm (carboxylate precursor)	92
32.	Silica	mesoporous silica SBA-15	Wet-chemical reduction	Water	$AgNO_3$	Sodium citrate	-	Solution stirred at 80 °C for 6 h and finally dried at 90 °C	Spherical Ag NPs of 7 nm and rod shaped Ag NPs of 7 nm in diameter of 60 nm in length formed	93
33.	Silica	HMS mesoporous silica	Wet impregnation method	Water	$AgNO_3$	H_2	-	Solution stirred at r.t. for 2 h, then dried at 100 ^oC in air followed by	Ag NPs of 20–200 nm and up to 2µm observed	94

								reduction with H_2 at 350 °C for 2 h	depending on the Ag loading	
34.	Silica	Mesoporous silica	Chemical reduction and impregnation	Water	$[Ag(NH_3)_2]+$ and Ag(I) chitosan complex	Glucose and $NaBH_4$	-	Solution stirred at r.t. for 1 h	Spherical and monodisperse Ag NPs with mean diameters of 13.3 nm and 26.6 nm formed	95
35.	Silica	Mesoporous silica microcapsule	Wet-chemical reduction	Water	$AgNO_3$	PVP (polyvinylpyrrolidone)	PVP (polyvinylpyrrolidone)	Solution first stirred at r.t. for 2 h and then calcined at 550 °C for 6 h	Ag NPs having diameters of 90 nm	96
36.	Silica	MCM-41 (Mesoporous silica)	Wet-chemical reduction	Ethylene glycol	$AgNO_3$	Ethylene glycol	PVP (polyvinylpyrrolidone)	Solution heated at 180 °C for 1 h, dried at 100 °C and then calcined at 500 °C for 4 h in air	Ag NPs majorly of sizes from 5 to 20 nm	97
37.	Metal oxide	Al_2O_3	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	3-mercaptopropionic acid (3-MPA)	0.1 N HCl added, mixture stirred at r.t. for 1 h and calcined at 823 K for 5 h, followed by treatment with H_2 at 473 K for 1 h	Ag NPs with mean diameters of 10 nm	98
38.	Metal oxide	Al_2O_3	Incipient wetness impregnation	Water	$AgNO_3$	-	-	Sample impregnated, dried and calcined and before reaction reduced in formier gas (10% H_2 in N_2) in tube oven at 300 °C for 1 h	Ag NPs with average diameters of 6.3 ± 1.4 nm	99
39.	Metal oxide	Al_2O_3	Successive ion layer adsorption and reaction (SILAR)	Water	$AgNO_3$	$NaBH_4$	-	Al_2O_3 film dipped for 10 s in aqueous $AgNO_3$ solution for multiple cycles	Ag NPs of sizes varying from 5 to 14 nm	100
40.	Metal oxide	Mesoporous MnO_2	Impregnation method	Water	$[Ag(NH_3)_2]OH$ synthesized from $AgNO_3$ and aqueous NH_3	-	-	Stirred for 4 h, dried at 100 °C and then calcined at 400 °C for 5 h	Ag NPs of 3–5 nm	101

41.	Metal oxide	MnO_2 nanowires	-	Water, acetone and ethanol	Ag foil	-	-	Ag foil sonicated in water, acetone and ethanol, then immersed in $KMnO_4$ while stirring followed by the addition of H_2SO_4 and stirred at r.t. for 24 h and finally solution kept undisturbed for 1 week	Monodisperse Ag NPs of 10 nm	[102]
42.	Metal oxide	CuO	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	PVP (polyvinyl pyrrolidone)	Mixture stirred at 25 °C for 2 h	CuO@Ag core-shell, with the CuO core in the size of 600 nm and the shell of 10 nm in thickness	[103]
43.	Metal oxide	CuO	Galvanic replacement reaction	Water	$AgNO_3$	-	-	Galvanic replacement after CuO particles added in $AgNO_3$ solution and stirred for 5 h	Platelet shaped Ag NPs of around 20-50 nm	[104]
44.	Metal oxide	ZnO	Biogenic greener approach	Water	$AgNO_3$	Electrons produced by electrochemically active biofilm (EAB) on carbon paper	-	Solution containing ZnO and $AgNO_3$ stirred for 5 min for Ag^+ adsorption on ZnO and then reduced by electrons produced by EAB in absence of air for 5 h.	Ag NPs in sizes of 7–12 nm	[105]
45.	Metal oxide	ZnO microrods	Photochemical reduction	Ethylene glycol	$AgNO_3$	-	-	Solution under constant stirring in photochemical equipment irradiated for 15 min by 500 W Xenon lamp	Ag NPs with sizes of 20–50 nm	[106]
46.	Metal oxide	ZnO nanoflowers	Wet-chemical reduction	Water	$AgNO_3$	Hydrazine hydrate	-	Solution stirred for 2 h for adsorption of Ag^+ on ZnO and obtained precipitate	Ag NPs with average sizes of 40 nm	[107]

								redispersed in water with addition of hydrazine hydrate under constant stirring		
47.	Metal oxide	CeO_2	Incipient wetness impregnation method	Water	$AgNO_3$	-	-	$AgNO_3$ and CeO_2 mixed under stirring, overnight aged at r.t., then dried at 80 ^oC for 12 h in oven and finally treated with 30% flow of O_2/Ar at 500 ^oC for 2 h	-	108
48.	Metal oxide	ZrO_2	Incipient wetness impregnation method	Ammonia and water	Ammonical solution of $AgNO_3$	-	-	Wet powder of ZrO_2 and $AgNO_3$ degassed in vacuum for 1 h, overnight dried at 100 ^oC and calcined at 650 ^oC for 8 h	Ag NPs with sizes 5-10 nm	109
49.	Metal oxide	WO_3	Impregnation method	Water	$AgNO_3$	-	-	Solution containing $AgNO_3$ and ammonium metatungstate hydrate stirred for 1 h at r.t., CTAB added, stirred for 3 h and finally dried at 110 ^oC for 12 h and heated in He flow at 500 ^oC for 6 h	Ag NPs with sizes in the range of 2–5 nm	110
50.	Metal oxide	TiO_2 nanotube	Wet-chemical reduction	Water, Ethylene glycol	$AgNO_3$	$NaBH_4$ and ethylene glycol	PVP (polyvinyl pyrrolidone)	TiO_2 nanotube mixed under static condition with $AgNO_3$ solution at 40 ^oC for 3,7 and 11 h	Ag NPs of 20 and 27 nm in size	111
51.	Metal oxide	TiO_2, Al_2O_3 and CeO_2	Impregnation method	Water	$AgNO_3$	-	-	Solution containing $AgNO_3$ and support stirred at r.t. for 1 h, excess water eliminated by rotatory-	Ag NPs of 3.4 nm in size in Ag/TiO_2, 11.3 nm in Ag/Al_2O_3 and around	112

								evaporator, dried overnight at 100 °C and calcined for 3 h at 450 °C	30 nm in Ag/CeO_2	
52.	Metal oxide	Fe_3O_4	Chemical reduction	Water	$AgNO_3$	Glucose	-	Mixture sonicated for 15 min and heated in water bath with slow stirring for 1 h	Mean size of Fe_3O_4-Ag core-shell was 46 nm	113
53.	Metal oxide	Iron oxide	Green synthesis	Water	$AgNO_3$	L-arginine	L-arginine	Mixture stirred at 70 °C for 8 h	Ag-iron oxide nanocomposite having a mean diameter of 13.8 ± 3 nm	114
54.	Boron nitride	Boron nitride	Wet-chemical reduction	Water	Silver acetate	Hydrazine hydrate	-	Solution stirred at r.t. for 30-40 min	Ag NPs with diameters ranging between 20 and 80 nm	115
55.	Boron nitride	Boron nitride	Microwave	DMF	$AgNO_3$	DMF	-	Mixture sonicated for 15 min and then exposed with microwave irradiations for 2-10 s	Ag NPs with diameters of 5–10 nm	116
56.	Boron nitride	Boron nitride	Pyrolysis method	Methanol	$AgNO_3$	-	-	Solution containing boric acid, urea and $AgNO_3$ heated at 55 °C till boiling and calcined at 900 °C for 5 h in N_2	Average size of Ag NPs on BN nanosheets was 176 nm	117
57.	Boron nitride	Boron nitride	Wet-chemical reduction	DMF	$AgNO_3$	DMF	-	Mixture sonicated and kept overnight for uniform distribution of Ag NPs	Uniform decoration of boron nitride nanosheets with Ag NPs	118
58.	Polymer	Polyacrylamide	Microwave	Ethylene glycol	$AgNO_3$	Ethylene glycol	Polyacrylamide	Solution irradiated with microwaves at 125 °C for 15 min	Ag NPs having diameters of 6–18 nm	119
59.	Polymer	Conjugated microporous polymer (CMP)	Simple liquid impregnation and light-induced reduction method	Water	$AgNO_3$	-	-	Solution containing polymer and $AgNO_3$ stirred overnight in dark and	Spherical Ag NPs with means diameter of 3.9 nm	120

								irradiated with xenon lamp as lamp source under stirring for 4 h		
60.	Polymer	Poly N-heterocyclic carbene (NHC)	-	DMSO	$AgNO_3$	-	-	Mixture stirred at r.t for 2 h followed by stirring at 80 °C for 10 h	Ag NPs with sizes of 3–5 nm	[121]
61.	Polymer	Polyvinyl alcohol (PVP)/ Polyvinyl pyrrolidone (PVP) nanocomposite film	Wet-chemical reduction	Water	$AgNO_3$	$NaBH_4$	-	O.1 M HNO_3 and glutaraldehyde added, stirred at r.t. for 2 h, followed by dipping in ice-cold $NaBH_4$ for 10 s	Spherical Ag NPs of around 15 nm in size	[122]
62.	Polymer	Chitosan-poly(3-hydroxybutyrate)	-	Water	$AgNO_3$	Chitosan-poly(3-hydroxybutyrate)	Chitosan-poly(3-hydroxybutyrate)	Stirred at 90 °C for 4 h	Quasi spherical Ag nanoparticles with particle size distribution of around 45 nm	[123]
63.	Zeolite	Porous 4A-zeolite	Thermal treatment	Ethanol	$AgNO_3$	-	-	Solution stirred at r.t., kept in supercritical CO_2 apparatus autoclave heated at 45 °C having pressure of 30 MPa for 6 h and calcined at 400 °C for 2 h	Uniformly distributed Ag NPs of around 5 nm	[124]
64.	Zeolite	Faujasite type (FAU) zeolite	Photochemical reduction	Water	$AgNO_3$	2-hydroxy-2-methyl propiophenone	-	FAU-Ag^+ suspension irradiated with 200 W Xe-Hg lamp for 60 s under constant stirring in a photoreactor	Ag NPs with diameters of 0.7–1.1 nm and 5–6 nm	[125]
65.	Zeolite	Mineral chabazite (MC)	Thermal treatment	Water	$AgNO_3$	-	-	Mixture stirred at 80 °C for 16 h, heated at 110 °C in argon flow for 30 min and calcined at 400 °C for 1 h in presence of argon	Ag nanoparticle with sizes of 4–9 nm	[126]
66.	MOF	MOF	Wet-chemical reduction	Acetonitrile	$AgNO_3$	$NaBH_4$	-	Mixture stirred for 12 h, methanolic	Ag NPs with average	[127]

								solution of $NaBH_4$ added with mixture kept in ice-bath and stirred again at r.t. for 4 h	sizes of 3.83 nm	
67.	MOF	MIL-100(Fe) and UiO-66(Zr)	Liquid impregnation technique	Acetonitrile	$AgNO_3$	$NaBH_4$	-	Stirred at r.t. for 12 h, dried at 100 °C and reduced with ethanolic solution of $NaBH_4$ in Ar for 3 h again dried at 100 °C	Ag NPs with sizes between 1 and 3 nm within MIL-100(Fe) and average diameters of 1.35nm in UiO-66(Zr)	128
68.	MOF	Fe_3O_4@MIL-100(Fe)	Radiation assisted route	Water and Isopropyl alcohol	$AgNO_3$	γ irradiations	-	Irradiated with ^{60}Co-γ-rays	Well dispersed Ag nanoparticles of 2 ± 0.8 nm	129
69.	Cellulose	Cellulose nanocrystals (CNC)	Dry milling assisted wet chemical reduction	-	$AgNO_3$	Ascorbic acid and cellulose nanocrystals	Cellulose nanocrystals (CNC)	$AgNO_3$ and cellulose milled in mortar for 30 min, kept for 24 h, ascorbic acid added and mixture again grounded for 30 min	Hexagonal shaped Ag NPs with diameters of 6–35 nm	130
70.	Cellulose	Cellulose extracted from stem of *Hibiscus sabdariffa*	Green synthetic route	Water	$AgNO_3$	Seed extract of *Hibiscus sabdariffa*	cellulose	Stirred at r.t. for 30 min	Uniformly distributed Ag nanoparticles with average sizes of 4 nm	131
71.	Cellulose	Nanocrystalline cellulose	Green synthetic route	Water	$AgNO_3$	Nanocrystalline cellulose	Nanocrystalline cellulose	pH maintained around 12 using NaOH and stirred at 65 °C for 2 h	Spherical Ag nanoparticles of around 20 nm	132

3.3 Mixed Ag NPs (~~Bimetallic~~ bimetallic ~~Alloys~~alloys, ~~Core~~core-shell and Janus NPs)

Table S3. Overall literature reports for preparing the mixed Ag nanocomposites.

S. No.	Method	Support	Solvent	Precursor	Reducing agent	Stabilizer	Conditions	Product description	Ref.
1.	Wet chemical co-reduction	-	DMF	$HAuCl_4$ and $AgNO_3$	DMF	PVP (polyvinyl pyrrolidone)	Reaction mixture refluxed at 156 °C for 1 h	Au/Ag bimetallic nanocubes in the edge length of 150 nm	133

2.	Wet chemical co-reduction	-	Water	$AgNO_3$	Ascorbic acid	PVP (polyvinyl pyrrolidone)	Aq. ammonia added to $AgNO_3$ and PVP solution followed by addition of $HAuCl_4$ and KI and stirred at r.t. for 15 min with subsequent addition of ascorbic acid	Au/Ag multispiked NPs with sizes between 70 and 130 nm	134
3.	Wet chemical reduction	-	Mesitylene	Nickel acetylacetonate and silver acetylacetonate	-	-	Mixture heated at 80 °C for 30 min and further heated with reflux at 200 °C for 2 h under flow of H_2 gas	Ag-Ni Snowman NPs with the size of Ni being 12.2 ± 3.1 and Ag being 11 ± 2.3 nm	135
4.	Green synthesis	-	Water	$HAuCl_4$ and $Ag(NH_3)_2OH$	Degraded pueraria starch (DPS)	Degraded pueraria starch (DPS)	Stirred for 24 h at r.t.	Spherical bimetallic Au/Ag NPs with average diameters of 32 nm	136
5.	Green synthesis	-	Water	$HAuCl_4$ and $AgNO_3$	Aqueous extract of Sago pondweed (*Potamogeton pectinatus L.*)	Flavones and proteins in aqueous extract of Sago pondweed	Mixture heated at 80 °C for 30 min	At pH =4, hexagonal, polyhedron Au/Ag bimetallic NPs with average sizes of 10.6 ± 5 nm and at pH =12 spherical NPs with average sizes of 6.6 ± 2.4 nm formed	137
6.	Wet chemical reduction	-	Water	$AgNO_3$ and $CuCl_2$	Glucose	Hexadecyl amine (HDA)	Mixture containing precursor salts, glucose and HDA stirred for 5 h and then heated at 100 °C for 2 h with vigorous stirring	Alloyed Cu/Ag bimetallic NPs of 85 nm with spherical morphology	138
7.	Light (radiolytic) methodology	-	Methanol	$AgClO_4$ and $NiSO_4$	Sodium citrate and γ radiations	Sodium citrate and polyvinyl alcohol	Solution deaerated by argon for 12 min and further irradiated with ^{60}Co-γ source for 18 min	Bimetallic Ag-Ni alloy NPs of various ratios with diameters ranging between 4 and 8 nm	139
8.	Laser mediated	-	Water	$HAuCl_4$ and $AgNO_3$	-	-	Solution irradiated with Nd:YAG laser with wavelength of 532 nm and 355 nm for 30 min	Bimetallic Au-Ag alloy NPs with spherical and sintered morphology	140
9.	Wet chemical reduction	-	Water	$FeSO_4$ and $AgNO_3$	$NaBH_4$	Sodium citrate	Aqueous $AgNO_3$ was injected to solution containing $FeSO_4$, $NaBH_4$ and sodium citrate after 1, 5 and 15 min	Bimetallic monodisperse Ag core (4 nm) and Fe shell (8 nm) formed after $AgNO_3$ injected after 1 min, Fe core and Ag shell formed after 5 min and Fe clusters of around 150 nm after 15 min were formed	141
10.	Wet chemical reduction	-	Water	$AgNO_3$	Ascorbic acid and NaOH	Sodium citrate	To solution containing Au seeds, NaOH for maintaining pH = 8.5. ascorbic acid and $AgNO_3$ added at r.t. and kept for 30 min	Au@Ag core shell NPs with diameters from 30 to 110 nm formed	142

11.	Sonochemical	-	Ethylene glycol	$HAuCl_4$ and $AgNO_3$	Ultrasonic irradiations	PEG (Poly Ethylene glycol)	Solution sonicated at r.t. for 30 min in argon atmosphere	Bimetallic Au@Ag NPs with diameters of 20 nm	143
12.	Microwave	-	Ethylene glycol	$HAuCl_4$ and $AgNO_3$	Ethylene glycol	PVP (polyvinyl pyrrolidone)	Solution irradiated with microwaves for 2 min	Au@Ag core-shell nanocrystals with triangular, square and rhombic, rods and wire morphology	144
13.	Wet chemical reduction	Carbon nitride (C_3N_4)	Water	$AgNO_3$, $AuCl_4$, K_2PdCl_4, K_2PtCl_4	$NaBH_4$	-	To solution containing C_3N_4/Ag, aqueous solution of $AuCl_4$, K_2PdCl_4, K_2PtCl_4 were added differently and stirred for 1 h to make C_3N_4/AgAu, C_3N_4/AgPd and C_3N_4/AgPt composites	In C_3N_4/AgPd, hollow and spherical bimetallic AgPd NPs with sizes around 18 ± 3 nm, in C_3N_4/AgPt hollow and spherical AgPt size of 9 ± 4 nm and in C_3N_4/AgAu spherical AgAu in the size of 14± 4 nm formed	145
14.	Wet chemical reduction	Carbon nitride nanotubes	Water	$AgNO_3$ and $CuNO_3$	$NaBH_4$	-	Suspension stirred at r.t. for 1 h and then aged for 90 min	Bimetallic Ag-Cu NPs with sizes around 10 nm on carbon nitride nanotubes	146
15.	Impregnation method	Carbon	Ethylene glycol	$AgNO_3$ and $Pd(OAc)_2$	Ethylene glycol	Polyvinyl pyrrolidone (PVP)	Solution containing carbon and PdAg colloidal solution was stirred for 48 h at r.t.	Uniform sized PdAg alloy NPs of sizes 3–5 nm formed	147
16.	Electrochemical reduction	Graphene paper	10 mM $CuSO_4$ and 10 mM $AgNO_3$ electrolyte	$CuSO_4$ and $AgNO_3$ Copper ring as anode and copper wire as cathode	-	-	Electrochemical deposition carried out using constant voltage of 4 V	Average size of Cu/Ag bimetallic dendrites (in equal ratio) on graphene paper was around 50 ± 5 nm through SEM analysis	148
17.	Wet chemical reduction	Graphene oxide	Ethylene glycol and water	$AgNO_3$ and $(NH_4)_2PdCl_6$	Ethylene glycol and urea	-	Solution stirred for 3 h and heated at 120 °C for 1 h	Bimetallic Pd-Ag NPs with average sizes of 5 nm	149
18.	Brust method, Galvanic exchange strategy followed by Langmuir–Blodgett method	Water/methanol (v/v = 1:1) solution	$AgNO_3$ and $HAuCl_4$	$NaBH_4$	Polar MPD ligands (stabilized the extra electron density on the gold sites)	Water/methanol (v/v = 1:1) solution	AgC6 Nanoparticles synthesized using Brust Method and mixed with $HAuCl_4$ and MPD in methanol with stirring at r.t. followed by interfacial galvanic exchange reactions between AgC6 nanoparticles and Au^I -MPD complex	AgAu Bimetallic Janus NPs with average core diameters of 5.70 ± 0.82, 5.79 ± 1.02, and 5.36 ± 0.85 nm	150
19.	Chemical etching methodology	-	Water	$AgNO_3$ and $HAuCl_4$	$NaBH_4$	Sodium citrate	Au@Ag semishell Janus NPs were prepared by etching off a part of the Ag shell from the Au@Ag core-shell NPs using a mixture of H_2O_2 and NH_4OH (1:1) water solution	Au core@Ag semishell Janus NPs with 6.4 ± 1.0 nm in diameter, as evidenced through the core-size histogram of TEM analysis	151

20.	One-pot controllable thermal decompositi on method	-	Water	Silver diethyldithioc arbamate (Ag–DEDTC) prepared using $AgNO_3$ and sodium diethyldithioc arbamate.	-	-	Thermal decomposition was carried out at 180 °C for 30 min under a N_2 atmosphere. Thereafter, thioglycolic acid was used for the preparation of Ag-Ag_2S JNPs coupled P25 TiO_2 composites	Eggplant shaped Ag-Ag_2S Janus particles of 10–40 nm.	152
21.	One-step co-precipitation technique	Cellulos e template	Water	$AgNO_3$	-	-	To a solution of NaOH-thiourea-urea H_2O of 8: 6.5: 8:77.5 ratio, cellulose was added under stirring, followed by addition of $AgNO_3$	Spherical Ag Ag_2S Janus NPs with the sizes ranging from 10 to 15 nm	153
22.	Pickering emulsion and combination of grafting from and grafting to approaches	Silica core with two polymeri c shells	Water	$HAuCl_4$ and $AgNO_3$	Triethyla mine	Polymer (PAA)	Bicomponent polymeric JPs were prepared using pickering emulsion using silica spheres to which ATRP initiator was added. Then, poly(tert-butyl acrylate) was grafted followed by grafting of carboxy terminated polystyrene (PS-COOH) onto PAA/NH_2-JP. Finally, $AgNO_3$ was added to a dispersed solution of PAA/PS-JP in water, followed by trimethylamine.	Janus particles of core diameters -200 nm and a shell comprising of two polymers polyacrylic acid (PAA) and polystyrene (PS).	154

3.4 AgO and Ag_2O NPs

Table S4. Reported protocols for synthesizing AgO and Ag_2O nanocomposites.

S. No.	Method	Support	Solvent	Precursor	Reducing agent	Stabilizer	Conditions	Product description	Ref.
1.	Thermal treatment	-	Water	$[Mg(NO_3)_2]$, AgO and glycine	-	-	Solution stirred at 185 °C, heated for 5 h in electrical heating mantle, annealed in furnace for 15 h at 900 °C	Mg doped AgO nanocube with average diameters of 20 nm formed	155
2.	Precipitation method	-	Water	$AgNO_3$	-	Glucose, sodium dodecyl benzene sulfonate (SDBS), sodium dodecyl sulfate (SDS) and cetyltrimethylamm onium bromide (CTAB)	Solution containing $AgNO_3$ and surfactant stirred for 30 min, $K_2S_2O_8$ and KOH added and stirred for 1 h at 50 °C	Agglomerated Nanosheets and NPs of AgO formed	156

3.	Sol-gel synthesis	TiO_2	Water	$AgNO_3$ and tetra-n-butyl titanate	-	-	Solution containing $AgNO_3$ and TiO_2 stirred for 30 min, $K_2S_2O_8$ and NaOH added and stirred at 50 ^oC for 1 h	AgO-TiO_2 nanocomposite in the size of around 30–40 nm	[157]
4.	Green combustion method	-	Water	$AgNO_3$	Cantaloupe seeds extract	-	Heated in muffle furnace at 500 ^oC for <5min	Spherical Ag_2O nanoparticles with diameters of 30 nm	[158]
5.	Green Combustion method	-	-	$AgNO_3$	*Centella Asiatica* and *Tridax* plant powder	-	Heated in muffle furnace at 600 ^oC	Spherical Ag_2O nanoparticles of 11–12 nm	[159]
6.	Photochemical reduction	TiO_2	Water	$AgNO_3$	UV radiations	-	Irradiated with 40 W UV lamp under stirring for 1 h	Ag_2O nanoparticles of 5-20 nm on TiO_2	[160]
7.	Wet chemical reduction	Mesoporous Silica	Water and methanol	$AgNO_3$	NaOH	-	Stirred at r.t. for 8 h	Cubic Ag_2O nanoparticles of 20–40 nm on mesoporous silica	[161]
8.	In-situ deposition	$Mg(OH)_2$ nanoplates	Water	$AgNO_3$	-	-	Stirred at r.t. for 12 h	Ag_2O nanoparticles of 5 nm on $Mg(OH)_2$ nanoplates	[162]
9.	Photochemical reduction	ZnO	Water and ethanol	$AgNO_3$	UV radiations	-	UV radiations for 30 min	Ag- Ag_2O nanoplates	[163]

References

1. I. Pastoriza-Santos and L. M. Liz-Marzán, *Nano Lett.*, 2002, **2**, 903-905.
2. K. Caswell, C. M. Bender and C. J. Murphy, *Nano Lett.,* 2003, **3**, 667-669.
3. A. Ben Moshe and G. Markovich, *Chem. Mater.*, 2011, **23**, 1239-1245.
4. G. S. Métraux and C. A. Mirkin, *Adv. Mater.*, 2005, **17**, 412-415.
5. D. Zhang, L. Qi, J. Yang, J. Ma, H. Cheng and L. Huang, *Chem. Mater.*, 2004, **16**, 872-876.
6. M. Pérez, R. Moiraghi, E. Coronado and V. Macagno, *Cryst. Growth Des.*, 2008, **8**, 1377-1383.
7. S. Banerjee, K. Loza, W. Meyer-Zaika, O. Prymak and M. Epple, *Chem. Mater.*, 2014, **26**, 951-957.
8. P. Sahoo, S. Kamal, T. J. Kumar, B. Sreedhar, A. Singh and S. Srivastava, *Def. Sci. J.*, 2009, **59**, 447-455.
9. K. Shameli, M. Bin Ahmad, S. D. Jazayeri, S. Sedaghat, P. Shabanzadeh, H. Jahangirian, M. Mahdavi and Y. Abdollahi, *Int. J. Mol. Sci.*, 2012, **13**, 6639-6650.
10. Y. Yang, S. Matsubara, L. Xiong, T. Hayakawa and M. Nogami, *J. Phys. Chem. C*, 2007, **111**, 9095-9104.
11. U. Nickel, A. zu Castell, K. Pöppl and S. Schneider, *Langmuir*, 2000, **16**, 9087-9091.

12. M. A. Raza, Z. Kanwal, A. Rauf, A. N. Sabri, S. Riaz and S. Naseem, *Nanomaterials*, 2016, **6**, 74.
13. I. Washio, Y. Xiong, Y. Yin and Y. Xia, *Adv. Mater.*, 2006, **18**, 1745-1749.
14. N. G. Bastús, F. Merkoçi, J. Piella and V. Puntes, *Chem. Mater.*, 2014, **26**, 2836-2846.
15. D. L. Van Hyning and C. F. Zukoski, *Langmuir*, 1998, **14**, 7034-7046.
16. M. Wuithschick, B. Paul, R. Bienert, A. Sarfraz, U. Vainio, M. Sztucki, R. Kraehnert, P. Strasser, K. Rademann and F. Emmerling, *Chem. Mater.*, 2013, **25**, 4679-4689.
17. Y. Sun, B. Mayers, T. Herricks and Y. Xia, *Nano Lett.*, 2003, **3**, 955-960.
18. Y. Sun and Y. Xia, *Adv. Mater.*, 2002, **14**, 833-837.
19. Y. Yin, Z.-Y. Li, Z. Zhong, B. Gates, Y. Xia and S. Venkateswaran, *J. Mater. Chem.*, 2002, **12**, 522-527.
20. D. Yu and V. W.-W. Yam, *J. Am. Chem. Soc.,* 2004, **126**, 13200-13201.
21. R. Salkar, P. Jeevanandam, S. Aruna, Y. Koltypin and A. Gedanken, *J. Mater. Chem.*, 1999, **9**, 1333-1335.
22. L. P. Jiang, S. Xu, J. M. Zhu, J. R. Zhang, J. J. Zhu and H. Y. Chen, *Inorg. Chem.,* 2004, **43**, 5877-5883.
23. M. Zhang, A. Zhao, H. Sun, H. Guo, D. Wang, D. Li, Z. Gan and W. Tao, *J. Mater. Chem.*, 2011, **21**, 18817-18824.
24. J. P. Zhang, P. Chen, C. H. Sun and X. J. Hu, *Appl. Catal., A,* 2004, **266**, 49-54.
25. Y. P. Zhu, X. K. Wang, W. l. Guo, J. G. Wang and C. Wang, *Ultrason. Sonochem.,* 2010, **17**, 675-679.
26. H. Xu and K. S. Suslick, *ACS nano*, 2010, **4**, 3209-3214.
27. S. Kundu, K. Wang and H. Liang, *J. Phys. Chem. C,*, 2009, **113**, 134-141.
28. B. Hu, S. B. Wang, K. Wang, M. Zhang and S. H. Yu, *J. Phys. Chem. C,*, 2008, **112**, 11169-11174.
29. L. Gou, M. Chipara and J. M. Zaleski, *Chem. Mater.*, 2007, **19**, 1755-1760.
30. M. N. Nadagouda and R. S. Varma, *Cryst. Growth Des.*, 2008, **8**, 291-295.
31. N. N. Mallikarjuna and R. S. Varma, *Cryst. Growth Des.*, 2007, **7**, 686-690.
32. B. Baruwati, V. Polshettiwar and R. S. Varma, *Green Chem.*, 2009, **11**, 926-930.
33. Y. Cai, X. Piao, W. Gao, Z. Zhang, E. Nie and Z. Sun, *RSC Adv.,* 2017, **7**, 34041-34048.
34. K. Seku, B. R. Gangapuram, B. Pejjai, K. K. Kadimpati and N. Golla, *J. nanostructure chem.*, 2018, **8**, 179-188.
35. S. Özkar and R. G. Finke, *J. Phys. Chem. C,*, 2017, **121**, 27643-27654.
36. G. A. Kahrilas, L. M. Wally, S. J. Fredrick, M. Hiskey, A. L. Prieto and J. E. Owens, *ACS Sustain. Chem. Eng.,* 2014, **2**, 367-376.
37. P. E. Saloga, C. Kästner and A. F. Thünemann, *Langmuir*, 2018, **34**, 147-153.
38. L. Adhikari, N. E. Larm, N. Bhawawet and G. A. Baker, *ACS Sustain. Chem. Eng.,* 2018, **6**,

5725-5731.

39. M. N. Nadagouda and R. S. Varma, *Green Chem.*, 2008, **10**, 859-862.
40. N. Aziz, M. Faraz, R. Pandey, M. Shakir, T. Fatma, A. Varma, I. Barman and R. Prasad, *Langmuir*, 2015, **31**, 11605-11612.
41. P. Raveendran, J. Fu and S. L. Wallen, *J. Am. Chem. Soc.,* 2003, **125**, 13940-13941.
42. J. L. Gardea-Torresdey, E. Gomez, J. R. Peralta-Videa, J. G. Parsons, H. Troiani and M. Jose-Yacaman, *Langmuir*, 2003, **19**, 1357-1361.
43. P. Sutradhar and M. Saha, *J. Phys. Chem. C,*, 2016, **120**, 8941-8949.
44. J. M. Ashraf, M. A. Ansari, H. M. Khan, M. A. Alzohairy and I. Choi, *Scientific reports*, 2016, **6**, 20414.
45. D. T. Rheder, M. Guilger, N. Bilesky-José, T. Germano-Costa, T. Pasquoto-Stigliani, T. B. B. Gallep, R. Grillo, C. dos Santos Carvalho, L. F. Fraceto and R. Lima, *Sci. Rep.,* 2018, **8**, 1-11.
46. Y. Xue, X. Qiu, Z. Liu and Y. Li, *ACS Sustain. Chem. Eng.,* 2018, **6**, 7695-7703.
47. S. Boopathi, S. Gopinath, T. Boopathi, V. Balamurugan, R. Rajeshkumar and M. Sundararaman, *Ind. Eng. Chem. Res.,* 2012, **51**, 5976-5985.
48. M. Kasithevar, M. Saravanan, P. Prakash, H. Kumar, M. Ovais, H. Barabadi and Z. K. Shinwari, *J. Interdiscip. Nanomed.,* 2017, **2**, 131-141.
49. M. N. Nadagouda, N. Iyanna, J. Lalley, C. Han, D. D. Dionysiou and R. S. Varma, *ACS Sustain. Chem. Eng.,* 2014, **2**, 1717-1723.
50. K. Jadhav, S. Deore, D. Dhamecha, R. Hr, S. Jagwani, S. Jalalpure and R. Bohara, *ACS Biomater. Sci. Eng.,* 2018, **4**, 892-899.
51. S. M. Hosseinpour-Mashkani and M. Ramezani, *Mater. Lett.,* 2014, **130**, 259-262.
52. M. Nakano, T. Fujiwara and N. Koga, *J. Phys. Chem. C,*, 2016, **120**, 8841-8854.
53. L. Gharibshahi, E. Saion, E. Gharibshahi, A. H. Shaari and K. A. Matori, *Materials*, 2017, **10**, 402.
54. M. Goudarzi, N. Mir, M. Mousavi-Kamazani, S. Bagheri and M. Salavati-Niasari, *Sci. Rep.,* 2016, **6**, 32539.
55. X. Z. Lin, A. D. Terepka and H. Yang, *Nano Lett.,* 2004, **4**, 2227-2232.
56. D. R. Kumar, M. Kasture, A. Prabhune, C. Ramana, B. Prasad and A. Kulkarni, *Green Chem.,* 2010, **12**, 609-615.
57. J. Huang, L. Lin, Q. Li, D. Sun, Y. Wang, Y. Lu, N. He, K. Yang, X. Yang and H. Wang, *Ind. Eng. Chem. Res.,* 2008, **47**, 6081-6090.
58. K.-J. Wu and L. Torrente-Murciano, *React. Chem. Eng.,* 2018, **3**, 267-276.
59. Y. Groisman and A. Gedanken, *J. Phys. Chem. C,*, 2008, **112**, 8802-8808.
60. S. Horikoshi, H. Abe, K. Torigoe, M. Abe and N. Serpone, *Nanoscale*, 2010, **2**, 1441-1447.
61. G. Dzido, P. Markowski, A. Małachowska-Jutsz, K. Prusik and A. B. Jarzębski, *J. Nanoparticle Res.,* 2015, **17**, 27.

62. X. Huang, B. Li, L. Li, H. Zhang, I. Majeed, I. Hussain and B. Tan, *J. Phys. Chem. C,* 2011, **116**, 448-455.
63. A. C. Garcia, L. H. Gasparotto, J. F. Gomes and G. Tremiliosi-Filho, *Electrocatalysis*, 2012, **3**, 147-152.
64. S. Guo, Q. Zhang, H. Li, H. Guo and W. He, *Nano Research*, 2017, **10**, 3261-3267.
65. Z. Wang, L. Xin, X. Zhao, Y. Qiu, Z. Zhang, O. A. Baturina and W. Li, *Renew. Energy*, 2014, **62**, 556-562.
66. T. Ji, L. Chen, M. Schmitz, F. S. Bao and J. Zhu, *Green Chem.,* 2015, **17**, 2515-2523.
67. J. Guo, A. Hsu, D. Chu and R. Chen, *J. Phys. Chem. C,* 2010, **114**, 4324-4330.
68. Y. Wang, Z. Liu, B. Han, Y. Huang and G. Yang, *Langmuir*, 2005, **21**, 10846-10849.
69. X. Lu, H. Qi, X. Zhang, Z. Xue, J. Jin, X. Zhou and X. Liu, *Chem. Commun.,* 2011, **47**, 12494-12496.
70. X.-Z. Tang, Z. Cao, H.-B. Zhang, J. Liu and Z.-Z. Yu, *Chem. Commun.,* 2011, **47**, 3084-3086.
71. Q. Bao, D. Zhang and P. Qi, *J. Colloid Interface Sci.,* 2011, **360**, 463-470.
72. Y. Li, Y. Cao, J. Xie, D. Jia, H. Qin and Z. Liang, *Catal. Commun.,* 2015, **58**, 21-25.
73. S. Liu, J. Tian, L. Wang and X. Sun, *Carbon*, 2011, **49**, 3158-3164.
74. Y. Zhang, X. Yuan, Y. Wang and Y. Chen, *J. Mater. Chem.*, 2012, **22**, 7245-7251.
75. W. Shao, X. Liu, H. Min, G. Dong, Q. Feng and S. Zuo, *ACS Appl. Mater. Interfaces,* 2015, **7**, 6966-6973.
76. E. K. Jeon, E. Seo, E. Lee, W. Lee, M.-K. Um and B.-S. Kim, *Chem. Commun.,* 2013, **49**, 3392-3394.
77. A. M. Golsheikh, N. Huang, H. Lim and R. Zakaria, *RSC Adv.,* 2014, **4**, 36401-36411.
78. A. Perdikaki, A. Galeou, G. Pilatos, I. Karatasios, N. K. Kanellopoulos, A. Prombona and G. N. Karanikolos, *ACS Appl. Mater. Interfaces,* 2016, **8**, 27498-27510.
79. S. K. Bhunia and N. R. Jana, *ACS Appl. Mater. Interfaces,* 2014, **6**, 20085-20092.
80. C. Xu and X. Wang, *Small*, 2009, **5**, 2212-2217.
81. A. Krainoi, C. Kummerlöwe, N. Vennemann, Y. Nakaramontri, S. Pichaiyut and C. Nakason, *J. Appl. Polym. Sci.,* 2019, **136**, 47281.
82. J. Zheng, X. Duan, H. Lin, Z. Gu, H. Fang, J. Li and Y. Yuan, *Nanoscale*, 2016, **8**, 5959-5967.
83. P. Singh, G. Lamanna, C. Ménard-Moyon, F. M. Toma, E. Magnano, F. Bondino, M. Prato, S. Verma and A. Bianco, *Angew. Chem. Int. Ed.,* 2011, **50**, 9893-9897.
84. X. Yan, S. Li, J. Bao, N. Zhang, B. Fan, R. Li, X. Liu and Y.-X. Pan, *ACS Appl. Mater. Interfaces,* 2016, **8**, 17060-17067.
85. M. K. Kundu, M. Sadhukhan and S. Barman, *J. Mater. Chem. B*, 2015, **3**, 1289-1300.
86. P. Veerakumar, C. Rajkumar, S.-M. Chen, B. Thirumalraj and K.-C. Lin, *J. Electroanal. Chem.,* 2018, **826**, 207-216.

87. S. B. Patel and D. V. Vasava, *ChemistrySelect*, 2018, **3**, 471-480.
88. S. Li, J. A. Bandy and R. J. Hamers, *ACS Appl. Mater. Interfaces,* 2018, **10**, 5395-5403.
89. J. C. Espinosa, S. Navalón, M. Álvaro and H. García, *ChemCatChem*, 2015, **7**, 2682-2688.
90. Z. -J. Jiang, C. -Y. Liu and L. -W. Sun, *J. Phys. Chem. B,* 2005, **109**, 1730-1735.
91. V. Raji, M. Chakraborty and P. A. Parikh, *Ind. Eng. Chem. Res.,* 2012, **51**, 5691-5698.
92. M. Steffan, A. Jakob, P. Claus and H. Lang, *Catal. Commun.,* 2009, **10**, 437-441.
93. B. Naik, S. Hazra, V. S. Prasad and N. N. Ghosh, *Catal. Commun.,* 2011, **12**, 1104-1108.
94. E. Charistoudi, M. G. Kallitsakis, I. Charisteidis, K. S. Triantafyllidis and I. N. Lykakis, *Adv. Synth. Catal.,* 2017, **359**, 2949-2960.
95. D. He, M. Kacopieros, A. Ikeda-Ohno and T. D. Waite, *Environ. Sci. Technol.,* 2014, **48**, 12320-12326.
96. H. Yang, Y. Liu, Q. Shen, L. Chen, W. You, X. Wang and J. Sheng, *J. Mater. Chem.*, 2012, **22**, 24132-24138.
97. Z. Chen and R. L. Luck, *Green Chem.,* 2016, **18**, 3354-3359.
98. K. Mori, A. Kumami, M. Tomonari and H. Yamashita, *J. Phys. Chem. C,* 2009, **113**, 16850-16854.
99. R. Poreddy, E. J. García-Suárez, A. Riisager and S. Kegnæs, *Dalton. Trans.,* 2014, **43**, 4255-4259.
100. K. G. Stamplecoskie and J. S. Manser, *ACS Appl. Mater. Interfaces,* 2014, **6**, 17489-17495.
101. B. Bai, Q. Qiao, H. Arandiyan, J. Li and J. Hao, *Environ. Sci. Technol.,* 2016, **50**, 2635-2640.
102. H. Xia, C. Hong, X. Shi, B. Li, G. Yuan, Q. Yao and J. Xie, *J. Mater. Chem. A*, 2015, **3**, 1216-1221.
103. N. Bouazizi, J. Vieillard, P. Thebault, F. Desriac, T. Clamens, R. Bargougui, N. Couvrat, O. Thoumire, N. Brun and G. Ladam, *Dalton. Trans.,* 2018, **47**, 9143-9155.
104. X. Chen, S. Ku, J. A. Weibel, E. Ximenes, X. Liu, M. Ladisch and S. V. Garimella, *ACS Appl. Mater. Interfaces,* 2017, **9**, 39165-39173.
105. S. A. Ansari, M. M. Khan, M. O. Ansari, J. Lee and M. H. Cho, *J. Phys. Chem. C*, 2013, **117**, 27023-27030.
106. Q. Deng, X. Duan, D. H. Ng, H. Tang, Y. Yang, M. Kong, Z. Wu, W. Cai and G. Wang, *ACS Appl. Mater. Interfaces,* 2012, **4**, 6030-6037.
107. P. Fageria, S. Gangopadhyay and S. Pande, *RSC Adv.,* 2014, **4**, 24962-24972.
108. Z. Qu, F. Yu, X. Zhang, Y. Wang and J. Gao, *Chem. Eng. J.,* 2013, **229**, 522-532.
109. L. Kundakovic and M. Flytzani-Stephanopoulos, *Appl. Catal. A,* 1999, **183**, 35-51.
110. S. Ghosh, S. S. Acharyya, T. Sasaki and R. Bal, *Green Chem.,* 2015, **17**, 1867-1876.
111. Y. Liang, Z. Cui, S. Zhu, Y. Liu and X. Yang, *J. Catal.,* 2011, **278**, 276-287.
112. J. Zhang, Y. Li, Y. Zhang, M. Chen, L. Wang, C. Zhang and H. He, *Sci. Rep.,* 2015, **5**, 12950.
113. D. Tang, R. Yuan and Y. Chai, *J. Phys. Chem. B,* 2006, **110**, 11640-11646.

114. J. R. Chiou, B. H. Lai, K. C. Hsu and D. H. Chen, *J. Hazard. Mater.,* 2013, **248**, 394-400.
115. Y. Lin, C. E. Bunker, K. S. Fernando and J. W. Connell, *ACS Appl. Mater. Interfaces,* 2012, **4**, 1110-1117.
116. G. Gao, A. Mathkar, E. P. Martins, D. S. Galvão, D. Gao, P. A. da Silva Autreto, C. Sun, L. Cai and P. M. Ajayan, *J. Mater. Chem. A*, 2014, **2**, 3148-3154.
117. J. Pang, Y. Chao, H. Chang, H. Li, J. Xiong, Q. Zhang, G. Chen, J. Qian, W. Zhu and H. Li, *ACS Sustain. Chem. Eng.,* 2018, **6**, 4948-4957.
118. A. Pullanchiyodan, K. S. Nair and K. P. Surendran, *ACS omega*, 2017, **2**, 8825-8835.
119. J. F. Zhu and Y. J. Zhu, *J. Phys. Chem. B,* 2006, **110**, 8593-8597.
120. H. L. Cao, H. B. Huang, Z. Chen, B. Karadeniz, J. Lü and R. Cao, *ACS Appl. Mater. Interfaces,* 2017, **9**, 5231-5236.
121. D. Yu, M. X. Tan and Y. Zhang, *Adv. Synth. Catal.,* 2012, **354**, 969-974.
122. W. H. Eisa, T. Abdel-Baset, E. M. Mohamed and S. Mahrous, *J. Inorg. Organomet. Polym. Mate.,* 2017, **27**, 1703-1711.
123. D. Silvestri, S. Wacławek, A. Venkateshaiah, K. Krawczyk, B. Sobel, V. V. Padil, M. Černík and R. S. Varma, *Carbohydr. Polym.,* 2020, **232**, 115806.
124. Y. Wu, C. Li, J. Bai and J. Wang, *Results Phys.,* 2017, **7**, 1616-1622.
125. M. Zaarour, M. El Roz, B. Dong, R. Retoux, R. Aad, J. Cardin, C. Dufour, F. Gourbilleau, J.-P. Gilson and S. Mintova, *Langmuir*, 2014, **30**, 6250-6256.
126. Y. Liu, Z. Zhu, G. Liu, Z. Xu, S. M. Kuznicki and H. Zhang, *J. Phys. Chem. C*, 2011, **115**, 14591-14597.
127. G. Dutta, A. K. Jana, D. K. Singh, M. Eswaramoorthy and S. Natarajan, *Chem. Asian J.,* 2018, **13**, 2677-2684.
128. N. N. Zhu, X. H. Liu, T. Li, J. G. Ma, P. Cheng and G. M. Yang, *Inorg. Chem.,* 2017, **56**, 3414-3420.
129. S. Chang, C. Liu, Y. Sun, Z. Yan, X. Zhang, X. Hu and H. Zhang, *ACS Appl. Nano Mater.,* 2020, **3**, 2302-2309.
130. W. H. Eisa, A. M. Abdelgawad and O. J. Rojas, *ACS Sustain. Chem. Eng.,* 2018, **6**, 3974-3983.
131. M. Goswami, D. Baruah and A. M. Das, *New J. Chem.,* 2018, **42**, 10868-10878.
132. H. Heidari and M. Karbalaee, *Appl. Organomet. Chem.,* 2019, **33**, e5070.
133. K. Jia, L. Yuan, X. Zhou, L. Pan, P. Wang, W. Chen and X. Liu, *RSC Adv.,* 2015, **5**, 58163-58170.
134. M. Sharma, P. R. Pudasaini, F. Ruiz-Zepeda, E. Vinogradova and A. A. Ayon, *ACS Appl. Mater. Interfaces,* 2014, **6**, 15472-15479.
135. C. Kim, B. L. Suh, H. Yun, J. Kim and H. Lee, *ACS Catal.,* 2017, **7**, 2294-2302.
136. B. Xia, F. He and L. Li, *Langmuir*, 2013, **29**, 4901-4907.
137. A. A. AbdelHamid, M. A. Al-Ghobashy, M. Fawzy, M. B. Mohamed and M. M. Abdel-

Mottaleb, *ACS Sustain. Chem. Eng.,* 2013, **1**, 1520-1529.

138. W. Wu, M. Lei, S. Yang, L. Zhou, L. Liu, X. Xiao, C. Jiang and V. A. Roy, *J. Mater. Chem. A*, 2015, **3**, 3450-3455.
139. Z. Zhang, T. M. Nenoff, K. Leung, S. R. Ferreira, J. Y. Huang, D. T. Berry, P. P. Provencio and R. Stumpf, *J. Phys. Chem. C*, 2010, **114**, 14309-14318.
140. Z. Peng, B. Spliethoff, B. Tesche, T. Walther and K. Kleinermanns, *J. Phys. Chem. B,* 2006, **110**, 2549-2554.
141. K. J. Carroll, D. M. Hudgins, S. Spurgeon, K. M. Kemner, B. Mishra, M. I. Boyanov, L. W. Brown III, M. L. Taheri and E. E. Carpenter, *Chem. Mater.*, 2010, **22**, 6291-6296.
142. A. K. Samal, L. Polavarapu, S. Rodal-Cedeira, L. M. Liz-Marzán, J. Pérez-Juste and I. Pastoriza-Santos, *Langmuir*, 2013, **29**, 15076-15082.
143. S. Anandan, F. Grieser and M. Ashokkumar, *J. Phys. Chem. C*, 2008, **112**, 15102-15105.
144. M. Tsuji, N. Miyamae, S. Lim, K. Kimura, X. Zhang, S. Hikino and M. Nishio, *Cryst. Growth Des.,* 2006, **6**, 1801-1807.
145. R. Nazir, P. Fageria, M. Basu and S. Pande, *J. Phys. Chem. C,*, 2017, **121**, 19548-19558.
146. Y. Zhu, A. Marianov, H. Xu, C. Lang and Y. Jiang, *ACS Appl. Mater. Interfaces,* 2018, **10**, 9468-9477.
147. M. Navlani-García, K. Mori, A. Nozaki, Y. Kuwahara and H. Yamashita, *Ind. Eng. Chem. Res.,* 2016, **55**, 7612-7620.
148. D. Li, J. Liu, H. Wang, C. J. Barrow and W. Yang, *Chem. Commun.,* 2016, **52**, 10968-10971.
149. J. Liu, H. Zhou, Q. Wang, F. Zeng and Y. Kuang, *J. Mater. Sci.,* 2012, **47**, 2188-2194.
150. Y. Song, K. Liu and S. Chen, *Langmuir*, 2012, **28**, 17143-17152.
151. L. Chen, C. P. Deming, Y. Peng, P. Hu, J. Stofan and S. Chen, *Nanoscale*, 2016, **8**, 14565-14572.
152. F. Jiang, Q. Tian, M. Tang, Z. Chen, J. Yang and J. Hu, *CrystEngComm*, 2011, **13**, 7189-7193.
153. D. Dutta, R. Hazarika, P. D. Dutta, T. Goswami, P. Sengupta and D. K. Dutta, *RSC Adv.,* 2016, **6**, 85173-85181.
154. A. Kirillova, C. Schliebe, G. Stoychev, A. Jakob, H. Lang and A. Synytska, *ACS Appl. Mater. Interfaces,* 2015, **7**, 21218-21225.
155. K. Kaviyarasu, E. Manikandan, J. Kennedy and M. Maaza, *RSC Adv.,* 2015, **5**, 82421-82428.
156. A. Sobhani-Nasab and M. Behpour, *J. Mater. Sci.: Mater. Electron.,* 2016, **27**, 1191-1196.
157. M. Akbari, A. Aetemady, F. Firoozeh and M. Yaseliani, *J. Mater. Sci.: Mater. Electron.,* 2017, **28**, 10245-10249.
158. S. Vinay, H. Sumedha, G. Nagaraju, S. Harishkumar and N. Chandrasekhar, *Appl. Organomet. Chem.,* 2020, e5830.
159. B. Rashmi, S. F. Harlapur, B. Avinash, C. Ravikumar, H. Nagaswarupa, M. A. Kumar, K. Gurushantha and M. Santosh, *Inorg. Chem. Commun.,* 2020, **111**, 107580.

160. D. Sarkar, C. K. Ghosh, S. Mukherjee and K. K. Chattopadhyay, *ACS Appl. Mater. Interfaces,* 2013, **5**, 331-337.

161. P. Das, S. Ray, A. Bhaumik, B. Banerjee and C. Mukhopadhyay, *RSC Adv.,* 2015, **5**, 6323-6331.

162. Y. Y. Chen, S. H. Yu, Q. Z. Yao, S. Q. Fu and G. T. Zhou, *J. Colloid Interface Sci.,* 2018, **510**, 280-291.

163. M. Y. Li, Y. Q. Mao, S. K. Yang, T. T. Dai, H. Yang, F. Feng, T. Wu, M. Chen, G. Q. Xu and J. H. Wu, *ACS omega*, 2016, **1**, 696-705.