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A review on Recent Non-hazard Eco friendly synthesized ZnO Nano-particles applied for diverse Applications

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Abstract *- This review, generally Zinc oxide nano-particles (ZnO NPs) synthesized using physical and chemical routes its produced hazardous wastage affect human health and environmental. This problems Overcome the eco-friendly green synthesis method applied to resent researchers. Green synthesis ZnO NPs prepared to various plant parts extract such as a leaf, flower, peels and seed as a percent in photochemical e.g. (flavonoids, phenols, etc.) It's applied to diverse applications such as photo-catalyst, optoelectronics, photovoltaic, optical sensor, biomedical and thin film applications. In this review discussed to eco-friendly formation and preparation methods, characterizations, and various applications have been reviewed.*

Key word: Green synthesis; ZnO NPs; diverse applications

1. INTRODUCTION

ZnO NPs are of great interest from technological and academic viewpoints owing to exclusive physical and chemical properties (Agnieszkakolodziejczak-radzimska., et al., 2014) large production and grate demant of ZnO NPs used in various physical and chemical techniques(Supattrasomsri et al.2016) such as chemical vapor deposition, sputtering, Pulsed laser deposition (Suresh et al.,2015) direct precipitation, sol-gel, sonochemicals, electro deposition (Thema et al.,2015) This Methods need for high temperature, vacuum, power supply hazardous chemicals (Nagajyothi et al., 2013;Susan Azizi et al., 2013) this problem over come to eco-friendly and green synthesis of ZnO NPs has become popular in recent year. It's very cheap, low cost synthesis (PriyabrataThatoi et al., 2016) Many green synthesis ZnO NPs procedure for have been reported for Bactria, yeast and Plants parts such as leaf(SupattraSomsri et al., 2016;) flower(RenataDobrucka et al., 2015) fruits (PandiyarasanVeluswamy et al., 2016) peel (ThenmozhiKarnan et al., 2016)etc.it's produced to different nanostructures can be reported.

This review focused green synthesis ZnO NPs used various plant extracts, formation of ZnO NPs, characterization and various applications discussed.

2. CHARACTERIZATIONS

Green synthesized ZnO Nanoparticles (ZnO NPs) formations are generally characterized by structure, size, morphology, surface roughness and disparity. homogeneity of these properties is important in many applications the commonly characterization of ZnO nano-particles are as follows The UV-Visible spectroscopy is a commonly used in ZnO NPs absorbance range is 200-400nm (SupattraSomsri et al., 2016) and plwant extracts absorbance. FT-IR spectroscopy is useful for vibration of molecules in organic functional groups presented plant extract and identify reduced/capping organic compounds in ZnO NPs(Nagajyothi et al.,2013) respectively.GS-MS as used to identified to major reacted component in ZnO NPs formation Elumalai et al., 2015; SiripiBalaji Reddy et al., 2017) The dynamic light scattering (DLS) used to determine the size of particle distribution and stability of ZnO NPs (Ambika et al., 2015; SiripiBalaji Reddy et al.,2017;), XRD is used for the crystalline structure and phase identification of the ZnO nanoparticles (IndranirekhaSaikia et al., 2015), Raman spectroscopy determine the structural defects and disorder (SiripiBalaji et al.,2016; Umaralikhan.,2017), AFM used in green synthesized ZnO NPs smooth, homogeneous and size range measurements (Elumalai et al., 2015) FE-SEM analysis the morphological at the micrometer scale to nanometer scale (Sathishkumar et al., 2017) elemental composition of ZnO NPs is commonly established using using (EDS) (NirananBala et al., 2015) and single nanoparticles unveiling a seious of analysible reticular distances closed measure at HR-TEM (Madam et al., 2015)

3. GREEN SYNTHESIS ZnO NANO-PARTICLES PROCEDURE

Mostly green synthesized ZnO NPs following combustion method. (Geetha. et al., 2016) reported ZnO NPs synthesized using latex was collected early sunrise in EuphorbiaceaeJatropha plant stem cut and get latex stored in a 4°C.10 ml DD Water dissolved 2ml, 4ml and 6ml of curde latex and add to each 1g of Zinc Nitrate mixed in magnetc stirrer after preheated 450± 10°C (5-10) min in muffle furnace with in less than 30min formed dehydrate its calcination 750°C at 2h.

(Suresh et al., 2015) prepared ZnO NPs using *Artocarpusgomezianus* fruit extract was reported by combustion method.

4. FORMATION OF GREEN SYNTHESIZED ZnO NANO-PARTICLES

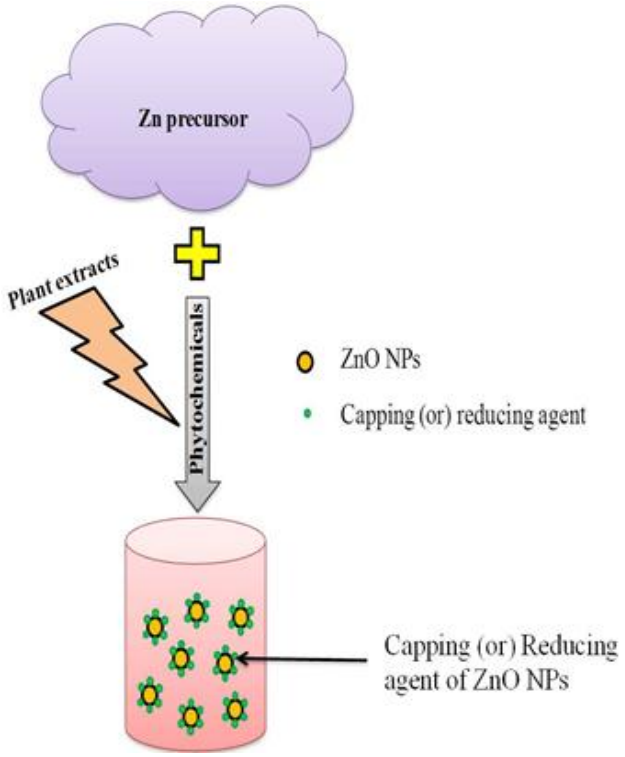

Fig.1.mechanisms of green synthesis ZnO NPs

Plant extract present in a many biological components such as a flavonoids, alkaloid and polyphenols (Ratul Kumar Das and SatinderKaurBrar, 2013; Elumalai et al., 2015) it as soluble in water the Zn precursor (zinc acetate, zinc nitrate) dissolving a Double distilled water after adding to the Plant extracts reducing and stabilize to the Zn^{2+} ironsshow in**(Fig.1)** mixed to constant stirring and heated a solution its formed to paste. It's a zinc hydroxide (Ambika et al., 2015) form it's heated to muffle furnace its converter to highly crystalline ZnO NPs and removing excess non-reacted components and water molecules. Plant extract presented phytochemicals as main role formed to ZnO NPs as many researchers reported (Sathishkumar et al., 2017; Diallo et al., 2015; Ambika et al., 2015).

5. GREEN SYNTHESIZED ZnO NANOPARTICLES USING A PLANT EXTRACTS

Green synthesis of ZnO NPs synthesized used plant parts used such as leafs, flowers, fruits, peels show the picture of plants part used for the green synthesis of ZnO NPs **(Fig.2)**ZnO NPs structure formation of dependent on plant present in phytochemicals and amount of added extract control particle size and shape of the NPs. show the**(Table.1)**

Table. 1. Phyto-chemicals present in plant extracts

S.NO	Plant name	Phytochemicals/biomolecules	Reference
1.	Aspalathus Linearis flower	Mostly present bioactive compoundsaspalathin, nothofagin, aspalalinin, lsoorientin, orientin,luteolin, eriodictyol	Diallo et al., 2015
2.	Courouita guianensis Aubl. Leaf	Leaf and fruit extract major contains phenols, Alkaloids,flavonoids and saponins	Sathishkumar et al.,2017
3.	Eucalyptus globulus leaf	Thujospene-13(10.15%),2-naphthalenemethanol(9.67%),β-sitosterol (5.740%), benzoic acid (5.23%),α-phellandrene (4.99%), eucalyptol (3.77%) as a major components	Siripi Balaji Reddy et al., 2017

(SekarVijayakumar et al., 2016)synthesizedflower shape ZnO NPs using a leaf extract of *Laurusnobilis* and showed them to be active grater against the gram positive and negative bactria (*staphylococcus aureus, pseudomonas aeruginosa*),antibioflim activity and A549 lung cancer cells has been reported.

(SiripiBalaji Reddy et al., 2016) synthesized spherical shape ZnO NPs using*Eucalyptusglobbulus* leaf power extract. ZnO reducing major components such as Thujospene-13 (10.15%), 2-naphthalene methanol (9.67%), b-sitosterol (5.740%), benzoic acid (5.23%), a-phellandrene (4.99%), eucalyptol (3.77%) and others(RajeswariRathnasamy et al., 2017) used an aqueous *Carica papaya*leaf extract and zinc acetate dihydracte mixed solution pH 8 maintained its produced aspherical shape ZnO NPs and average particle size as 50nm.(Umaralikhan et al., 2017) reported optical properties of ZnO NPs (42 nm) have been synthesized using a *Psidiumguajava* leaf extract.(PriyabrataThatoi., 2016)reported in Oxime and heterocyclic compounds importance source for ZnONPs synthesized using *Heritiera forms* leaf and *Sonneratiaapetala*leaf extract applied in biomedical applications. (Ambika et al., 2015) used aqueous extract *Pongamiapinnata*Leaves to produced 100nm spherical shape ZnO NPs treated cotton tested antibacterial activity

Fig.2. green synthesis ZnO NPs using plant parts

5. APPLICATIONS OF GREEN SYNTHRSIS ZnO NANOPARTICLES

Green synthesis ZnO NPs used many applications as tabulated show in **(Fig.3** and **Table: 1)** Green synthesis route as a more benefits show in **Fig.2** its rapid process developed in recent years.

(HakanColak et al., 2016) reported to lemon peel extract synthesis spot like nanostructure ZnO thin films are very good optical quality and high transparency.

(MuthuchamyMaruthupandy et al., 2016) testified in ZnO NPs prepared in Camellia japonica leaf extract, ZnO NPs detected from metal ions using optical sensor applications, test from different metal ions concentration from (10µM-100µM) of (Ag^+, Li^+, Hg^+, Fe^+, Pb^+, Ni^+, Cd^+, K^+, Cr^+ and Mn^+), ZnO NPs 301nm peak reduced in increasing concentration of 10µM-100µM Ag^+ solution color changed from light yellow to colorless, ZnO NPs detected from Ag^+ ions its binding biomolecules from NPs surface and reduced absorbance band its used to purification process in marine water.

(PandiyarasanVeluswamy et al., 2016) described to Avocado fruit extract prepared clustral of coral shape, flower shape, ovoid shape and spherical shape obtained changing the experimental conditions, Thermal conductivity analysis in different temperature range 298k to 673k, thermal conductivity increase and decrease depended in various shape 0.75, 0.34, 1.36, and0.57 Wm^{-1} K^{-1}ZnO flower nanostructure better thermal conductivity of 0.34 to 0.22Wm^{-1}.

(GunalanSangeetha et al., 2011) reported for aloe vera leaf extract concentration > 25% zinc nitrate converted in> 95% spherical structure ZnO nanoparticles it's highly stable.

(SolletiGoutham et al., 2017) reported Aloe vera plant extract synthesized ZnO NPs reported 1000 ppm Liquid Petroleum Gas sensing at 250°C closed in chemically prepared ZnO NPs.

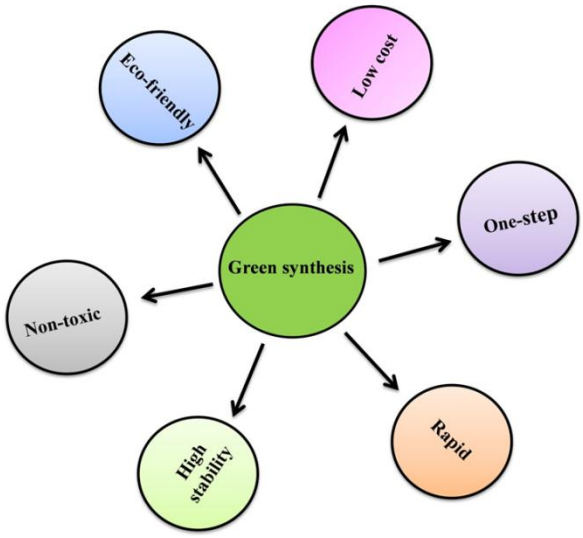

Fig.2. Benefits of green synthesis

(RajeswariRathnasamyetal.,2017)synthesized~50nm ZnO NPs using a carica papaya leaf, ZnO film coated FTO plate Dye sensitized solar cell (DSSCs) its produced results previous literature reported better then higher efficiency of DSSCs. open circuit voltage of 51mV, current density of 8.12 mA cm^{-2}, fill of factor 38%, and over all energy conversation efficiency 1.6%.

(Archana et al.,2016) reported in (2ml, 6ml,10ml, 14ml) moringaoleifera natural extract and 10ml of water dissolved at 2.97g zinc nitrate hexahydrate. After synthesized ZnO NPs catalyst H_2 evolution rate 341.9µmol g^{-1} in ZnO-10 it's compare to bulk and other nanostructures. And H_2 production experiment in various amount of catalyst (10mg, 20mg, 30mg) using a ZnO-10 NPs.H_2 production range (66.96µmolg^{-1}, 341. 9µmolg^{-1}, 28.13µmolg^{-1}) 10 and 30 mg better then H_2 produced 20mg catalyst in 2houres.

(RajeswariRathnasamy et al., 2017) synthesized ZnO NPs using Carica papaya leaf. 0.03 g Spherical shape ZnO NPs loaded 30mL of 100µM MB dye solution degradation of within 180 min under UV light.

(Hakancolak et al., 2017) synthesized ZnOnanoparticles achieved 70-86% optical transmittance .Its good structural homogeneity and crystalline of the ZnO nanoparticles. Using Aesculushippocastanum fruit shell extracts is acting as complexing agent.

(Ambika et al., 2015) used pongamiapinnata leaf extract synthesized ZnO NPs and treated cotton fabric tested against S.aureus and E.coli bacteria. Zone of inhibition S.aureus 29mm and E.coli 25mm.at concentration ZnO NPs (100µg/ml)

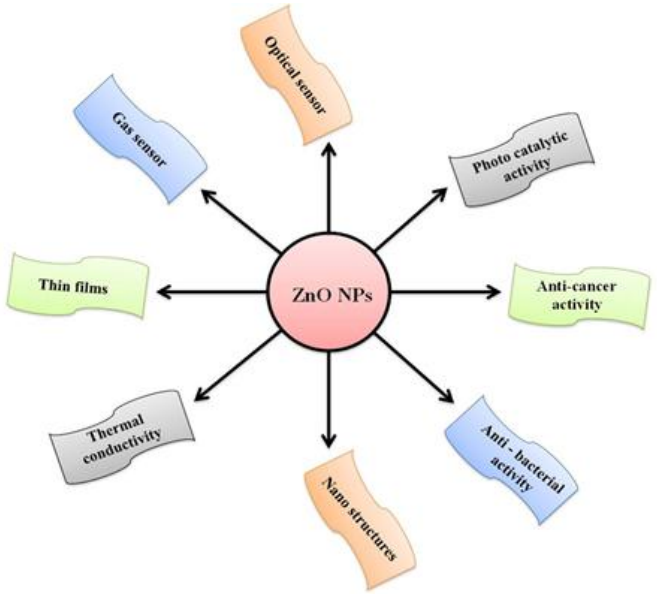

Fig.3.Various application of green synthesis ZnO NPs

(Preeti Mishra et al. 2016) reported rare earth metal gadolinium(Gd) is (1, 3, 7 mol %) dopedCaralluma fimbriata plant extract synthesized ZnO NPs it's formed various nanostructures 1mol% Gd^{3+}doped ZnO formed small irregular shaped balls its aggregated to flower bunds shape, 3mol% Gd^{3+}doped ZnO formed buds grows extended and increased 7mol% Gd^{3+}doped ZnO formed hexagonal shaped flakes agreed bell shaped flowers many literatures reported Gd^{3+}improved photocatalytic activity of the catalyst.(1mol %)Gd doped ZnO NPs (30mg)dispersed 250ml of 20ppm indigo carmine dye solution has reach 98%and 90% under UV light and Sunlight irradiation for 90min respectively. Repeated results for six cycles.

(Kaviya et al., 2016) studied at direct sunlight under achieved 95% MB degradation using pomegranate peel extract synthesized ZnO nanopencil structure.

(Vidya et al., 2016) using Artocarpus heterophyllus leaf extract mediated ZnO NPs size range 15 to 20 nm degradation of Rose Bengal dye (< 80%, 0.24g/L) achieved in one hour.

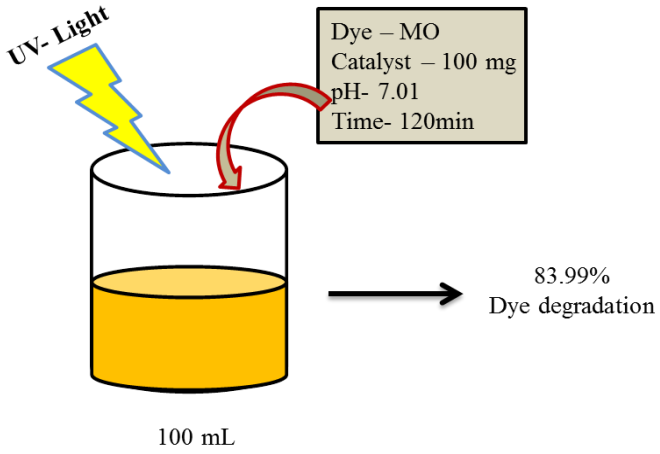

Fig.4. Rambutan peel synthesized ZnO NPs react to MO dye

(ThenmozhiKarnan et al., 2016) using rambutan (Nepheliumlappaceum L.) peel extract synthesized spherical shaped 100 mg ZnO NPs 83.99% degradation of 100 ml Methyl Orange (MO) dye solution under UV light in 120 minutes show in **(Fig:4)**

SI. NO	PLANT NAME	APPLICATIONS	REFERANCE
1	Lemon peel	Thin film	HakanColak et al., 2016
2	Avocado fruit	Thermal conductivity	Pndiyarasan Veluswamy et al.,2016
3	Camellia japonica leaf	Optical sensor	Muthuchamy Maruthupandyet al.,2016
4	Moringaoleifera	H_2 generation	Archana et al 2016
5	Aloevera plant	Gas sensor	SolletiGoutham et al.,2017
6	Carica papaya leaf	Photovoltaic	RajeswariRathnasamy et al., 2017
7	Aesculushippocastanum fruit shell	Optoelectronics	Hakancolak et al ., 2017
8	Pongamiapinnata leaf	Antibacterial activity	Ambika et al., 2015
9	Laurusnobilis leaf	Anti-cancer activity	SekarVijayakumar16

Table: 1 Green synthesis ZnO NPs used applications

CONCLUSION:

ZnO Nano-particles preparation will be selected green synthesis method is a very safe and very easily large scale prepared nanoparticlesthe green approach produced controlled size and morphology eco-friendly ZnO NPs utilized to several applications .Researchers also focused on plant extract mechanism as well detection and characterization of biomolecules involved in the stabilization and formation of ZnO nanoparticles and improved green approach will develop in feature works.

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