REVIEW OF LITERATURE

Gambhire et al., (2014) reported the synthesis of anatase TiO$_2$ nanoparticles by sol-gel method which were doped with various metals and non-metals and studied their photocatalytic behavior by degrading MB. The prepared photocatalyst exhibited smaller shape particles and higher specific surface area. The high photocatalytic activity of the C-TiO$_2$ under visible light irradiation can be attributed to smaller particle size, high specific surface area, optical absorption and displayed photocatalytic activity in the visible region.

Kapusuz et al., (2013) successfully synthesized composites by doping and co-doping B and Zr ions in anatase TiO$_2$ lattice by using sol-gel method to show increased photocatalytic performance to higher levels. It was concluded that photocatalytic activity of TiO$_2$ increased by doping with B and Zr which result in formation of oxygen vacancies in crystal and also forming Ti$^{4+}$ defects which result in formation of more energy levels and thus increase the photocatalytic activity.

Matejova et al., (2013) studied the photocatalytic reduction of carbon dioxide with the newly synthesized gold enriched TiO$_2$ and TiO$_2$-ZrO$_2$ catalysts which are prepared by sol-gel process. It was shown that photocatalytic activity decreases over Au/TiO$_2$-ZrO$_2$ and Au/TiO$_2$ compared to parent counterparts. It can be explained by presence of too large Au particles which block oxide surface and either reduce the light absorption capability of catalysts or serve as recombination centre.

Sasikala et al., (2013) reported that hybrid photocatalyst of ZrO$_2$-TiO$_2$-CdS nano size showed enhanced photocatalytic activity for hydrogen generation from water as compared to its constituent single phase oxides. The increased activity of multi component catalyst is attributed to decreased particle size of CdS and increased lifetime of the charge carriers resulting from the efficient interfacial transfer of photo generated electrons at the CdS/TiO$_2$ and CdS/ZrO$_2$ interface.

Du et al., (2013) synthesized a series of Ho-Zr-O nanocomposites with the help of sol-gel method. Photosynthetic experiments demonstrated that Zr-Ho-O nanocrystals have excellent visible-light responsive photocatalytic activities on dyes which result from the special defect structures, better absorption of visible light and large specific surface area.
Kokporka et al., (2013) synthesized the nanocomposites of mesoporous TiO$_2$-ZrO$_2$ and showed the improved photocatalytic activity by production of H$_2$ under visible light irradiation. Addition of ZrO$_2$ to TiO$_2$ leads to thermal stability of TiO$_2$ even at 800 °C and also retards the transformation of anatase to rutile form.

Park et al., (2013) studied semiconductor TiO$_2$ photocatalysts as well as the latest modifications of TiO$_2$ photocatalyst to improve the photocatalytic activities for an advanced oxidation process.

McManamon et al., (2013) examined the effect of addition of various dopants to TiO$_2$ nanocomposites for the enhancement of photocatalytic activity. The various dopants used were Ag, Zr and S and were found to be efficient in doping.

Das et al., (2013) studied the preparation of composites of new series of Ti$^{4+}$ by co-precipitation of homogeneous solution metal salts. The derived mixed oxides demonstrated better activity towards photodegradation of methylene blue and rhodamine B than those of a physical nature of ZnO and TiO$_2$.

Wang et al., (2013) examined the photo-stability of titanium dioxide by coating it with zirconium, cerium as well as some other transition metal oxides. It was shown that these coating materials significantly improve the photo-stability of TiO$_2$ particles, even with a small coated amount.

Mattsson et al., (2012) synthesized Zr and Y co-doped TiO$_2$ nanocomposite and studied its characterization, phase stability, surface chemical and photocatalytic properties.

Liu et al., (2012) reported that cerium-doped SiO$_2$/TiO$_2$ nano structured fibers were prepared by a facile sol-gel method and checked its effect on the degradation of methylene blue (MB) under simulated sunlight irradiation. The 0.2% Ce-doped SiO$_2$/TiO$_2$ fibers exhibited higher photocatalytic activity towards decomposition of MB.

Kim et al., (2012) studied the preparation of visible light responsive zirconium-doped TiO$_2$/SiO$_2$ photocatalyst by sol-gel process. It was found that doping of TiO$_2$ with suitable amounts of SiO$_2$ and zirconium can enhance its photocatalytic activity. The addition of SiO$_2$ suppress the particle size and TiO$_2$ phase transformation from anatase to rutile and promote thermal stability of composite. The addition of zirconium results in finer, more uniform particles and increased surface acidity of the TiO$_2$ catalysts due to formation of stronger surface OH groups. The
absorption spectrum of Zr doped TiO$_2$/SiO$_2$ catalyst shifted significantly to visible light region as compared to TiO$_2$ alone.

Andronic et al., (2011) studied the photochemical synthesis of copper sulphide/titanium oxide photocatalyst and checked its dye degradation efficiency (methyl orange and methylene blue) under UV and visible light irradiation. The enhanced activity of composite was explained by the irreversible charge separation, decrease in the kinetic constraints when interacting with the dye molecules.

Kambur et al., (2011) reported the preparation of TiO$_2$-ZrO$_2$ binary oxide nanoparticles and evaluated its performance for the photodegradation of phenol. The catalytic activity of binary oxide in 50% wt ratio was found to be high.

Wang et al., (2011) worked on the preparation of a novel CdS/La$_2$TiO$_4$ nanocomposite photocatalyst working under visible light. The prepared photocatalyst showed enhanced visible light absorption and exhibited efficient photocatalytic activity for decomposition of MO under UV and visible light irradiation.

Mu et al., (2011) prepared Si-doped TiO$_2$ nanoparticles with anatase crystalline phase by a hydrothermal method using acetic acid as a solvent. The photoelectrochemical results show that doping of suitable amount of Si in TiO$_2$ help in fast movement of electrons towards cathode. This can be described by the easy transfer and separation of photogenerated electrons and holes.

Murugesan et al., (2011) successfully synthesized Zr$^{4+}$, La$^{3+}$ and Ce$^{3+}$ doped mesoporous TiO$_2$ materials by sol-gel method and evaluated their photocatalytic activity.

Gao et al., (2010) successfully reported the incorporation of Zr ion into the bulk lattice of TiO$_2$ by a multi-step sol-gel process. The Zr-doped TiO$_2$ photocatalysts exhibited much higher photocatalytic efficiency than pure TiO$_2$ in the degradation of bisphenol A under UV irradiation and complete mineralization of BPA was achieved. The higher photocatalytic activity of Zr doped TiO$_2$ was attributed to gradually upward shift of the conduction bands with increasing Zr content, thus resulting in a stronger reduction power of photogenerated electrons and contributing to the improved photoactivity.

Mishra et al., (2010) studied hydrazine mediated synthesis of high surface area and thermally stable N-doped zirconium titanium mixed oxide with enhanced photocatalytic activity towards
reduction of selenium (vi) to Se$^0$ under visible light. Enhancement in activity was explained by increase in pore volume.

Liu et al., (2009) prepared Zr doped TiO$_2$ nanotube arrays by electrochemical method and studied photocatalytic activity with Rhodamine B. The results demonstrated that the photocatalytic efficiency of Zr doped TiO$_2$ nanotubes was much better than that of TiO$_2$ nanotubes.

Rehman et al., (2009) explained about the strategies of making TiO$_2$ and ZnO visible light active. Among the various techniques employed to make TiO$_2$ sensitive to visible light, co-doping of nanometals has produced the most significant results.

Liu et al., (2008) synthesized mesoporous CaO-ZrO$_2$ nano-oxide composite which act as a solid base with both high activity and high stability.

Danciu et al., (2008) explored the preparation of TiO$_2$-ZrO$_2$ aerogels and worked on their photocatalytic activity. The best catalytic activity was obtained for 9.39% Zr in mixed oxide.

Tang et al., (2008) reported the preparation of nano-CaO using thermal decomposition method.