NANO ZINC OXIDE IN PAPER-BASED PRODUCTS

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INTRODUCTION

Zinc oxide having chemical formula, ZnO is a type of inorganic mineral that exists as white powder form and insoluble to water. It has pH 6.95 which cause bitter in taste and high melting point up to 1,975°C. This is the reason of its suitability to be applied in ceramics and electronics products recently. Zinc oxide is a common commercial substance in pharmaceutical industries in instance first-aid tapes and calamine cream for the purpose to treat skin condition problem (rashes and wound) (National Center for Biotechnology Information (NCBI), 2005). The occupation of zinc-oxide at industrial scales production also involved rubber, cosmetics, textile, electronics and electrotechnology, photocatalysis, biosensor and production of zinc silicates as exhibited in Figure 1.

Zinc oxide is eminent as a multi-functional mineral due to its chemical and biological characteristics by having high chemical stability, high photostability, wide range of radiation absorption and high electrochemical coupling coefficient (Segets et al., 2009; Lou et al., 1991). Currently, industries and researchers acquire higher attention in advancing nano-zinc oxide that has been treated as amongst promising nanomaterials owing its unique characteristics such as antimicrobial, photocatalytic, electro conductivity and ultraviolet protection (Kolodziejczak-Radzimska & Jesionowski, 2014)

Researcher has studied the effectiveness of zinc oxide to the extent of nano-sized particles in various products. In obvious research case, nano-zinc can be employed in

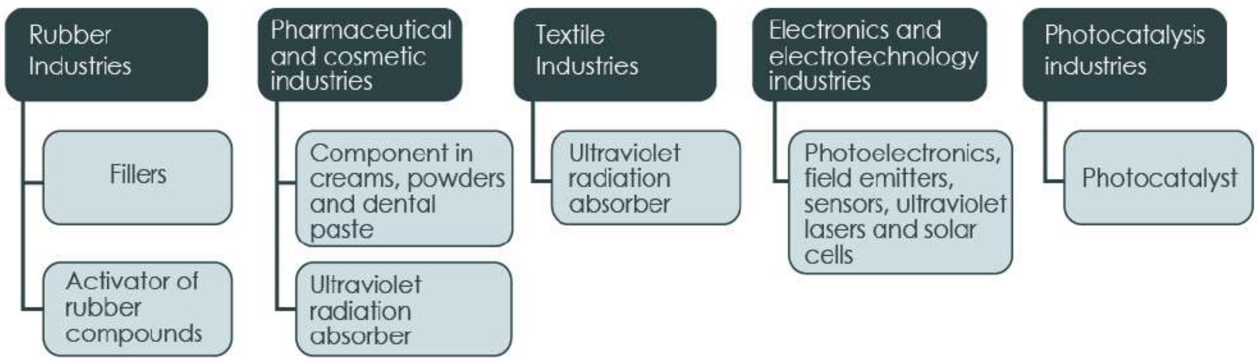

Fig. 1. The application of zinc oxide in industries (Kolodziejczak-Radzimska & Jesionowski, 2014)

treating effluent to reduce microbial load (Nagarajan & Kuppusamy, 2013). As for paper-based application, researcher investigated that nano-zinc oxide coated paper has exhibited higher quality printing paper (Prassad et al. 2010). In addition, the paper brought along the ability of absorbing ultraviolet which can avoid induction of ultraviolet degradation beneath it. A study by Jaisai et al., (2012) also consuming nano-zinc oxide that are grown on paper via hydrothermal method and has shown good antimicrobial activity against Escherichia coli and Staphylococcus aureus. The potential of the antimicrobial paper to inhibit microbes is enhanced by its photocatalysis properties as shown by Baruah et al., (2010) with immobilization of E. coli under visible-light irradiation.

Looking at nano-zinc performance in various application via research and industries persepective therefore it is being treated as amongst promising nanomaterials owing to its unique properties such as antimicrobial substance. This is due to smaller size of zinc oxide particles that can provide larger surface areas to work more efficient. Environmental Working Group (EWG) (2018) applied nano-zinc oxide in their sunscreens product to formulate less white chalky lotion and greater sun protection factor. Besides, the nano-sized zinc oxide is transparent in visible light which make it suitable in certain products like textile, pharmaceutical and cosmetics (DaNa, 2013).

In papermaking area, there are 2 types of nano-zinc oxide preparation which consist of chemical and biological methodologies. According to Jaisai et al. (2012), nano-zinc oxide that have been hydrothermally-synthesized achieved 250-300 nm and 3,400-4,200 nm in width and length respectively. Catalyst like gold plays important role in defining the nanowires zinc oxide diameter by directing its growth as long as the catalyst remains in liquid state with reactant. Sublimation of zinc oxide powder without catalyst produced nanobelt zinc oxide with typical width for entire length 50-300 nm and 10-30 nm thickness (Wang, 2004). Biological preparation method involves bio-resources and few chemicals as precursor or solvents for extraction process. Plants, algae and fungi are some example of the sources that can be utilized to initiate the growth of nano-zinc oxide. Sutradhar & Saha (2015) used green tea leaf as reducing and stabilizing agent for zinc oxide nanoparticles under microwave irradiation. Nano-zinc oxide can be varied in size and shape for example the sol-gel method with solution-based approach studied by Srivastava, et al., (2013), produced rod-shape zinc oxide nanoparticles in range of 17-50 nm via Transmission Electron Microscopy (TEM).

Nano-zinc oxide has become promising in nanomaterials industries because of its functional properties which can be applied as antiseptic and anti-inflammation due to its antimicrobial property as stated by Prasad et al., (2010). The researchers investigated that no fungal growth was noticed on nano-zinc oxide coated paper while base paper was completely degraded by fungus. Exhibiting strong visible fluorescene was excited by ultraviolet corresponds to wide band gap emission of nano-zinc oxide which makes it good ultraviolet absorber. Photocatalytic activity of nanorods zinc oxide paper studied by Baruah et al., (2010) showed high percentage of photodegradation for methylene blue and methyl orange, and also nominal decrease of efficiency though after several times usage. Sobri et al. (2018) found out that zinc-oxide particles can be produced via in-situ synthesis by using hydrothermal methods which may allow the generation of nano-zinc particles amount and shape that contributes to its characteristics.

In addition, there are few established paper-based products in the market which could provide brighter future for modified nano-zinc oxide paper. The company namely as Paper Products Company (2015) focused on the sanitary and food packaging items. The food packaging items include paper bowls, boxes for cake and pizza, paper cups, paper plates, and facial tissue. Similar to Eco Carton (2016), wide range of food and beverages paper-based packaging has been produced in Malaysia. Being popular for its antimicrobial activity, Wallsauce (2019) has intended to use such particles for wall paper which possible to reduce breeding and minimize spreading of bacteria and mould in moisture and indoor environment respectively. Such paper may be applied for safe and artsy wall for hotels, health institution and even for home and work places. This property could also benefit in health care paper-based products such as face mask, tissue paper and paper for printing and writing bringing along antimicrobial characteristics.

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