POSSIBLE TRENDS OF RENEWABLE ORGANIC FILLERS AND PIGMENTS DERIVED FROM NATURAL RESOURCES FOR SUSTAINABLE DEVELOPMENT OF PAPERMAKING INDUSTRY

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The use of traditional inorganic fillers and pigments for both filling and coating applications in papermaking may have certain limitations in such aspects as recyclability and combustibility. Novel renewable organic fillers and pigments derived from natural resources can possibly be completely recyclable, combustible, biodegradable, and environmentally friendly, and they can potentially be used as substitutes for inorganic fillers and pigments to improve the recyclability and other properties of the paper products. Although there are still challenges lying ahead, the strategic significance of the use of renewable organic fillers and pigments for the sustainable development of papermaking industry is an indisputable and demonstrable fact.

Keywords: Renewable fillers and pigments; Papermaking; Recyclability; Combustibility; Biodegradability; Environmentally friendly; Natural resources; Sustainable development

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Benefits and Possible Challenges Associated with the Use of Traditional Inorganic Fillers and Pigments in Papermaking

In the papermaking industry, inorganic fillers and pigments have been widely used for filling and coating applications, and these chemicals have been indispensable raw materials for the paper products. The use of inorganic fillers and pigments can provide many benefits. Brightness, optical properties, printability (smoothness, ink adsorption/affinity, and print show through), sheet formation, and dimensional stability of the paper products, can be improved, and cost savings, energy reductions, as well as improved machine speed can also be provided.

During the recycling process of paper products manufactured using inorganic fillers and pigments as part of the raw materials, non-fibrous materials are separated from the fibers, and the resulting sludge can possibly consist of ink particles, fiber residues, inorganic fillers and pigments, other impurities, and water. Of the sludge, its organic component may be burned, and the remaining ash is often disposed of in landfill sites. Under certain conditions, the paper products can also end up directly for final disposal (landfill or combustion) after primary use. Although the inorganic components of deinking sludge may also be recovered using specific technologies to produce such products as fillers and pigments, in the long run, the recyclability of paper products has possible limitations due to the presence of large amounts of inorganic wastes, which is surely inconsistent with the development trend of a sustainable papermaking industry.

Renewable Organic Fillers and Pigments Derived from Natural Resources as Substitutes for Inorganic Fillers and Pigments

In recent years, the potential value of development of renewable organic fillers and pigments has been relatively widely accepted. For example, researchers in VTT Technical Research Center of Finland, University of Helsinki, University of Joensuu, Western Michigan University, Geological Survey of Finland, Luleå University of Technology, and North Carolina State University have already conducted relevant research work on the development of organic fillers and pigments for papermaking, using starch as the base raw material. Recently, researchers in Korea developed lignocellulosic fillers for papermaking using wastewood (logging residues) as the base raw material. The use of renewable fillers and pigments can increase the recyclability of the paper products, and can possibly change especially the amount of waste deposited in landfill sites. The relevant paper products, being substantially free of inorganic fillers and pigments, can be completely recyclable, combustible, and biodegradable. Compared with inorganic fillers and pigments, the renewable organic starch-based ones can give higher paper strength (surface, tear, tensile, and internal bond strength) and lower basis weight. In these respects, the use of renewable organic fillers and pigments has potential to reduce paper handling and logistical costs, and these materials are less harmful for wood fibers, less abrasive for paper machine components (wires, cutters etc), and more environmentally friendly. Also, during the recycling process of the paper products manufactured using renewable organic fillers and pigments, the organic waste can be easily burned to produce energy (fuel oil). Additionally, the use of renewable organic fillers and pigments can possibly facilitate the functionalization of paper, as the natural polymers can perhaps be easily modified, functionalized, or engineered.

If the environmentally friendly renewable organic fillers and pigments produced from natural resources (such as starch) are successfully and widely used in the papermaking industry, sustainable development can potentially be achieved, which will surely create countless benefits in the future.

Challenges and Possible Debates

Although the use of renewable organic fillers and pigments can potentially provide many benefits, there are still certain challenges. When starch is used as the base raw material to obtain starch-based fillers and pigments, although the optical characteristics of fillers and pigments can possibly be well optimized by carefully controlling particle size, particle size distribution, and structure of the particles, there are surely limitations associated with the economics of the relevant technologies, and certain technological difficulties concerning industrial manufacturing and application may also exist. For lignocellulosic fillers derived from wastewood, they can possibly be obtained via certain mechanical and chemical treatments, and the manufacturing costs may be economically acceptable; however, poor optical properties are likely to be the key weaknesses limiting their successful applications. Their use as only a partial substitute for inorganic fillers is possibly more feasible. Surface brightening or encapsulation of lignocellulose fillers might possibly be needed to improve their properties.

In recent years, development of more cost-effective and environmentally friendly recycling of paper products has been a very hot topic. The inorganic fillers and pigments

present in the resulting deinking sludge can possibly be recovered more widely and successfully with the further development and improvement of relevant technologies. Also, novel synthetic inorganic fillers and pigments (or synthetic organic ones derived from petroleum chemicals) with specifically desired properties, and high-yield pulp, can potentially be used in the manufacturing of paper products with relatively low basis weight. Thus, some people may argue against the significance of renewable organic fillers and pigments principally on the basis of relatively high costs or low performances in specific industrial applications, and there is perhaps still a long way to go as far as successful large-scale application of renewable organic fillers and pigments is concerned. However, in the long run, the worldwide successful industrial application of high-performance renewable organic fillers and pigments in papermaking is undoubtedly of strategic significance, and real sustainable development can be realized.

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