

論 文 内 容 要 旨

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学位論文題目	Utilization of kenaf fibers as a flexible support for indium zinc oxide thin films and as a sacrificial template of nanostructured tubular TiO ₂ through dip-coating method (ディップコーティング法によるインジウム亜鉛酸化物薄膜の支持体およびナノ構造管状酸化チタン作製のためのテンプレートとしてのケナフ繊維の有効利用)		
内容要旨 <p>The study on the utilization of kenaf fibres as a flexible support and sacrificial templates for the synthesis of high surface area nanostructured TiO₂ presents novel avenues for industrial applications. It will also offer an easy, alternative, and economical processes for production. It is well known that kenaf fibres possess good mechanical strength and high flexibility. Therefore, KF is suitable flexible support for an electroconductive thin film with high electroconductivity. Furthermore, KF is carbon neutral under air combustion. Non-woven kenaf possesses uniform diameters of several micrometres wide. Therefore, it is considered a sacrificial template for nanostructured tubular materials. The dip-coating method was applied to form the surrounding structure around the kenaf fibres and control its crystallinity. Other benefits of applying the dip-coating method are low-temperature control which is suited with the material properties of kenaf fibres.</p> <p>The first novelty of this study was the investigation of the electrical conductivity of the indium zinc oxide-modified kenaf fibre (KF-IZO) with emphasis on its morphology and the dipping rate as required for dip-coating and annealing process applications. The KF was alkalinized using a 5% solution of sodium hydroxide (NaOH) whereas the dipping rate was varied from 1 to 30 mm/s. Next, the KF-IZO was annealed at 150, 175 and 200 ° C for 2, 4, 6, and 8 hours. A modified four-probe method employing a copper metal attachment plate was used to evaluate the electrical properties of KF-IZO. A dipping rate of 5 mm/s at 150 ° C annealed temperature, which yielded the highest electrical conductivity of 11.81 S/mm, was the observed optimum. Furthermore, the electrical resistivity of KF-IZO at 4 hours of annealing time showed the lowest resistivity of 0.12 Ω .mm. However, the highest resistivity of 12.62 Ω .mm was obtained at 16 hours of annealing time. Scanning Electron Microscope/Energy Dispersive X-Ray (SEM-EDX) analysis of KF-IZO revealed the IZO film was uniformly coated on the KF substrates without significant thermal damage. KF-IZO showed potential for application in smart textiles, electrostatic discharge protection, and as reinforcement in composites.</p> <p>The second novelty of this study was the production of tubular TiO₂ using kenaf natural fibre as a sacrificial template. The tubular TiO₂ nanostructures were</p>			

synthesized in a single step by depositing titanium (IV) isopropoxide precursor on kenaf fibres. In the calcination temperature range 500-700 ° C, the synthesized tubular TiO₂ predominantly contained the anatase phase. X-ray diffraction studies were performed to examine the crystallinity and crystallite size of the tubular TiO₂ synthesized while its photocatalytic activity was examined by monitoring the degradation of methylene blue (MB) under ultraviolet irradiation. The results showed that tubular TiO₂ formed at 500 ° C exhibited the smallest crystallite size of 9.27 nm and fastest photocatalytic oxidation rate. In summary, KFs can serve as an effective, abundant, and inexpensive template material for the synthesis of nanostructured tubular TiO₂ with a high surface area. To conclude, the empirical evidence presented in this thesis proves that kenaf fibres work as flexible support for IZO thin films as well as a sacrificial template of nanostructured tubular TiO₂ by applying a dip-coating technique on the fibres. Also, the determine objectives has been achieved throughout the thesis.

There are some recommendations for future works of KF-IZO such as to study other kinds or form of natural fibre, carry out an investigation of the different kinds of dopant material such as B, Al and Ga to increase the electrical conductivity of the ZnO thin films and also study various techniques like RF magnetron sputtering to ease or control the growth of thin films thickness on natural fibre surfaces. Meanwhile for tubular TiO₂, the recommendations such as study the pH value since the structured forms of TiO₂ directly affected the photocatalytic activities could be considered. Also, perform a different wavelength of UV light during the photocatalyst test because it could give different photocatalytic performance for TiO₂.