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Feasibility of beer brewing using nano-biocatalyst synthesised from yeast cells and carbon nanotubes

Higginson, Antony James

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Abstract

The feasibility of utilising a nano-biocatalyst produced using yeast cells and carbon nanotubes for beer fermentation was examined. Carbon nanotubes were used as a site for physical adsorption for the yeast cells. As the use of carbon nanotubes in the production of consumable products is contentious due to the relatively unknown toxicity of carbon nanotubes, a method was developed to anchor the carbon nanotubes to a stainless steel substrate. Direct synthesis of carbon nanotubes on the surface of the stainless steel produced mainly amorphous carbon and reduced the corrosion resistance of the steel when performed at 950^{o}C and hence was disregarded as a method to produce a carrier for yeast cell immobilization. Deposition of nanotubes produced through floating catalyst chemical vapour deposition resulted in a horizontally aligned film of nanotubes. Due to the weak bonds with the surface of the stainless steel, the film degraded in water and was not a viable carrier for yeast cell immobilization. By using pre-deposition of the ferrocene catalyst, prior to carbon nanotube synthesis at 850^{o}C, using acetylene as the carbon source and argon as an inert process gas, vertically aligned carbon nanotubes with diameters ranging from 20 nm to 50 nm formed a densely packed film ranging from 20 µm to 50 µm thick. The resultant vertically aligned carbon nanotube film was then combined with yeast cells and the resultant biocatalyst was tested for feasibility of use in beer fermentation. The biocatalyst was found to be non-viable as the surface coverage of yeast cells, at a yeast loading of less than 0.13 g of yeast per m^2 of biocatalyst, was too low to provide adequate fermentation kinetics. The effect of the cell immobilization on the fermentation products could not be determined due to the low surface coverage of yeast cells on the biocatalyst. Furthermore the carbon nanotube film was found to degrade during fermentation due to hydrodynamic forces and mechanical wear. As this would result in contamination of the final product, the biocatalyst is unsuitable for beverage production. The yeast cells that were in contact with the carbon nanotube film showed morphological changes due to the strong interactions between the carbon nanotubes and the walls of the cells, but continued to divide and grow. As the carbon nanotubes did support cell growth and the cells were adhered strongly to the surface, carbon nanotubes could be used as a biocatalyst in situations where formation of a biofilm is desirous such as in waste water treatment and biomedical scaffolds.