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Thermal degradation of microcrystalline cellulose in concentrated phosphoric acid as assessed by HPLC, high field NMR spectroscopy and low field NMR relaxometry

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The most common renewable fuel is ethanol. It is a liquid produced by fermentation of glucose which is very abundant in cellulose based material sources. Plants produce about 180 billion tons of cellulose per year globally. For this reason cellulose is the largest organic carbon reservoir on Earth.
Cellulose is composed exclusively of glucose units linked via β-1,4 glycosidic bonds. Each D-(+)-glucose unit contains three hydroxyl groups, which can form complex spatial networks of inter- and intra- molecular hydrogen bonds. They are responsible for the high crystallinity and compactness of cellulose, thereby making it very resistant to biological and chemical attack.
In the presence of mineral acid, cellulose is known to undergo hydrolysis whose extent depends on acid concentration, reaction temperature and treatment duration. Cellulose depolymerization is followed by formation of hydrocellulose, soluble polysaccharides, oligosaccharides and/or glucose as by products.
Aim of the present study was to evaluate kinetic of glucose formation during cellulose degradation by using 85% phosphoric acid. H3PO4 is a weak mineral acid, non corrosive, non toxic and safer to use as compared to other inorganic mineral acids. It was investigated the role of residence time on the efficiency of glucose release during the hydrolysis of microcrystalline- cellulose in H3PO4 at the constant reaction temperature of 80°C.
Results showed the presence of two competitive reactions. In the interval between 5 and 90 minutes, the system is dominated by cellulose hydrolysis with glucose formation with a kinetic costant of 0.0058 $\pm$ 0.0004 mM/min. Above 90 minutes, the reaction appeared dominated by glucose degradation. Glucose yield resulted of 28% after 90 minutes, thereby indicating that 1.5 h, at 80 °C allows the production of the largest amount of glucose from crystalline cellulose.