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Efficient and Selective transformation of carbohydrates to valuable chemicals via sonochemistry: which essential parameters to control the reaction?

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PURPOSE OF THE ABSTRACT

Ultrasound, previously employed for echography, surface cleaning, welding or telemetry, is now attracting a growing interest as a clean energy activation technology among the organic chemistry community; the term sonochemistry has thus been coined.1-3 The implosion of cavitation bubbles generated by ultrasound locally induces high temperatures (up to 5,000 K), pressures (up to 1,000 bar), shockwaves, microjets (up to 100 m.s-1), radical formations and solvated electrons.4,5 In contrast to the popular low frequency ultrasound (20-80 kHz) which mainly induce physical effects,6 sonication at high frequency (> 150 kHz) produces large quantities of small size cavitation bubbles and their implosion releases enough energy to break chemical bonds.7-10 For instance, the homolytic cleavage of molecular oxygen inside the collapsing bubble was shown feasible at high ultrasonic frequency.11,12

To date, high frequency ultrasound (HFUS) has been essentially employed for the total catalyst-free oxidation of low concentration of aqueous pollutants.13,14 The mechanism involves several reaction pathways such as pyrolysis inside the cavitation bubble and hydroxyl radical-mediated reactions. In this work, we reveal that, working under dilute concentration of carbohydrates (< 10 wt. %) (glucose) leads to the selective oxidation of glucose to glucuronic acid (94 % yield) (under oxygen bubbling), while high concentration of glucose (40-80 wt %) leads to a pyrolysis-like mechanism with levoglusan observed as reaction intermediate, for subsequent oligomerization reactions.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

BIBLIOGRAPHY