OC-47: Detection of oh Radicals in the Process of Hydrodynamic Cavitation and in A Sonoreaktor Using a Luminescence Method

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As Gogate P.R. (2004) notes the interest to the physical and chemical processes proceeding in condition of hydrodynamic cavitation (HDC), which initiates and activates the chemical reaction, increases. It should be noted, that there are many methods, which are used to study the chemical processes proceeding in condition of hydrodynamic cavitation. First of all it is the methods of determinations of OH-radicals number as an indicator of the process effectiveness. The small number of radicals generated in the conditions of the HDC can be estimated using a fluorescent method. In this method terephthalic acid (TA) is used as a trap (Iida Y., 2005). This method is unique due to its sensitivity, and TA interacts with OH-radicals selectively, with other intermediates such as $HO^{\bullet}_2$, H_2O_2, $O^{\bullet-}_2$, $H^{\bullet}$, does not interact. The minimum sensitivity of detection of OH-radicals terephthalate dosimeter is equal $1{,}2\cdot10^{11}$ OH radicals $mL^{-1}\cdot s^{-1}$. Terephthalate method is based on measuring of the intensity of the fluorescence spectrum of oxidation product of terephthalic acid (TAOH or 2-hydroxide terephthalate). The molecule TAOH excited by a photon (λ_{em} = 315 nm) fluoresces which great intensity (λ_{ex} = 425 nm). Generally this methods is used for the detection of the OH-radicals, which being formed in solution when exposed to ultrasound, ultraviolet etc. There is no evidence about using this method to the study of the formation of OH-radicals in HDC.

In this research we used different methods to generate cavitation in aqueous solutions of TA to evaluate the sensitivity of the proposed method. First of all it is the well known and widely used method, which is based on application of ultrasound. We used piezo element operating with frequency 1MHz to generate ultrasound. As a result we determined the optimal concentration of TA $5\cdot10^{-5}$ mol/l. However the main objective of the research is application of terephthalate dosimeter for an efficiency assessment, in particular for an assessment of OH-radicals. The absence of cavitation was noted at pressure below 1 atm, and concentration growth in the conditions of cavitation at pressure of 5 atm is clearly visible. Earlier in Batoyev's (2010, 2011) works the critical pressure, at which cavitation arises for nozzles of different diameters, was experimentally revealed and theoretically calculated. The obtained experimental data don't contradict calculation. So for the nozzle with diameter of 4 mm the critical pressure, i.e. the pressure of beginning of cavitation, is equal P=1.34 atm. For a detailed understanding of the nature phenomena occurring in the cavitation chamber we carried out computer simulations using a fluid dynamics software package Flow-3D.

To evaluate energy influence of HDC the comparative experiments were made. At these experiments in solution except TA was also present a hydrogen peroxide, or ethyl alcohol. It is known that the binding energy with OH group increases in a row HO-OH, C_2H_5-OH and H-OH, therefore the oxidation rate of TA in solution in the presence of hydrogen peroxide will be maximal. This fact is indicated by experimental data. It should be noted that the results presented above without hydrogen peroxide in the conditions of HDC, show low efficiency of this process in comparison with the results obtained with use of ultrasound. The reasons of this fact have not been studied yet.

References

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