Decomposition of Organic Waste by DC Water Thermal Plasmas

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Thermal plasms have been demonstrated an effective means for non-degradable liquid and gas waste treatment. Thermal plasmas have attracted extensive attention for its high enthalpy and chemical reactivity.

A DC water plasma torch for liquid and gas waste treatment was developed by authors.[1] By means of water plasma, the decomposition of high concentration organic compounds like phenol[2] and acetone[3] was demonstrated successfully. A new torch was developed by authors, [4] in which the solution was introduced into the jet by atomization with an ultrasonic transducer.

The purpose of this study is to investigate the decomposition mechanism of organic waste by water thermal plasma at atmospheric pressure.

Figure 1 shows the schematic diagram of the DC water plasma system. The decomposition system consisted of a DC power supply, a non-transfer plasma torch and a reaction tube. The plasma torch consists of a nozzle-type copper anode, the cathode was made by hafnium with a diameter of 1.0 mm, embedded into a copper rod.

The solution was fed into the jet as a mist by an ultrasonic disc. After arc ignition, water plasma was generated at the discharge region, heating the solution, then both vapor and mist were fed into the discharge region, cooling the anode simultaneously. Thus the torch can operate in a long time at atmospheric pressure without any carrier gases or cooling water, leading to a relatively higher energy efficiency comparing with a traditional thermal plasma torch, and a low cost was also achieved.

N, N-dimethylformamide (DMF) is a typical hazardous component which is widely used in organic and polymer production processes, due to its high solubility in organic and inorganic solvents. Thus, a large amount of DMF containing wastewater was discharged from a variety of industrial plants every year. Because of its high stability, DMF was found difficult to degrade, and resistant to photochemical decompositions.

The solution of DMF was successfully decomposed by the water plasma, with the current of 7.5 A and voltage of 160-220 V. The effect of DMF concentration on decomposition rate and energy efficiency was presented in **Fig. 2**. The average decomposition rate was more than 96 % in all conditions, and decrease slowly with the increase of concentration, while the energy efficiency increase with the concentration non-linearly, and reached about 40 g/kWh at the condition of 5 mol%.

Gas and liquid products were analyzed, the major gas products were H_2 and CO, which was about 90 %, while a small amount of NO was detected during high concentration DMF decomposition. The high temperature and O, H radical in water thermal plasma inhibited the formation of byproducts like NO_x. Water thermal plasma showed promising potential in non-degradable nitrogen-containing organic pollutants.

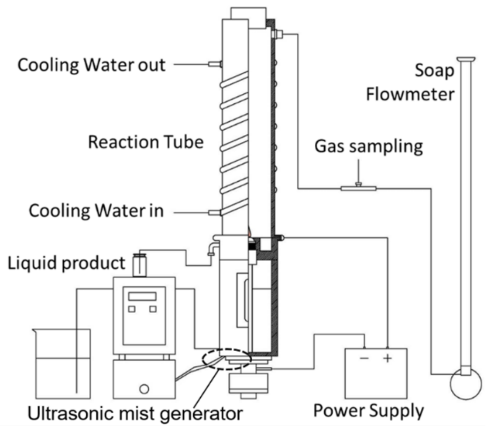

Fig. 1 Water plasma system for waste decomposition.

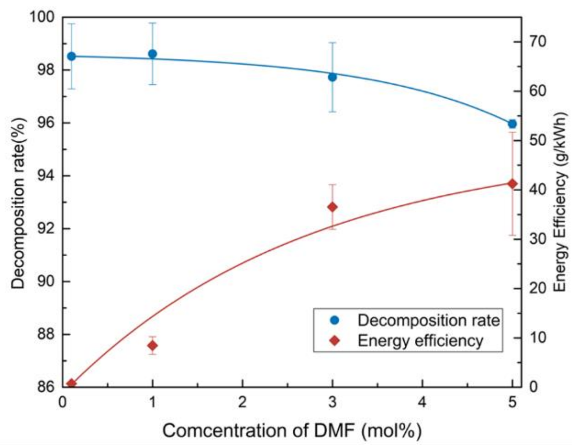

Fig. 2 Decomposition rate and energy efficiency for DMF decomposition.

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