Report for AC21 Special Project Fund (2013)

Project Title: Development of sono-process for green innovation and the applications in environment (Joint research between small groups of researchers)

AC21 partners: Prof. XiaoJun Liu (Nanjing University)
Prof. Keiji Yasuda (Nagoya University)
Prof. WenXiang Hu (Tongji University)

Background: Cavitation bubbles can vibrate, grow, shrink and eventually burst under ultrasound irradiation. In the process of cavitation, extremely high temperatures (thousands of degrees), high pressure (thousands of times of atmospheric pressure) and jets at speeds of a few hundred meters per second will be generated. The chemical reaction due to ultrasonic cavitation is known as a sonochemical reaction. Thus, the degradation of high environmental pollution chemicals such as organic or acidic solutions can occur by sonochemical reaction at room temperature and normal pressure. However, the reaction efficiency of general sonochemical reaction devices is low, especially in industrial applications. Developing high-efficiency sonochemical reaction devices is a necessary path for promoting the further development of applications for sonochemistry.

Purpose of Project: This cooperative project integrated the advantages of the three universities (Nanjing University, Nagoya University and Tongji University) and focused on how to maximize the efficiency of ultrasonic sonochemical reactions. It included ultrasonic reactor design by introducing acoustic metamaterials to adjust the intensity, study of the effects on the ultrasonic reactor by adjusting the physical parameters of ultrasound (multi-frequency and pulse wave), and so on. The project combined theoretical and experimental methods to develop a new high-efficiency ultrasonic reactor, which can be used to degradate environmental wastewater. Nanjing University has extensive experience with sound field simulation inside ultrasonic reactors and the dynamics of the cavitation bubble during sonochemical reactions. Tongji University has rich experiences of the design and fabrication of high power ultrasonic transducers. Nagoya University has a unique advantage in the fabrication of sonochemical reactors and experimental methods. We sought to develop a high-efficiency practical sonochemical reactor by the combination and promotion of Nanjing University's theory and simulation, Tongji University's design of high power transducers and Nagoya University's fabrication and experimental observation of reactors. The other purpose of this project was to optimize the efficiency of high-efficient sonochemical reactors to degradate high environmental pollution chemicals. The researchers from Nagoya University have deeply studied ultrasound and its cooperation with ozone, UV, etc to promote the treatment of wastewater. This cooperative project was carried out through inter-university visits, participating in seminars, group discussion, and the graduate students from all three universities studying and writing academic papers.

Project Description: A cooperative research project (NSFC and JSPS project) was proposed by Nanjing University and Nagoya University. However, this cooperative research was limited to exchange between the professors at these two universities. The proposed AC21 project was realized on exchanges between researchers, including graduate students from the three universities

that took part. Three graduate students, Mr. Kyosuke Mochida from Nagoya University, Mr. Zheng Xu from Tongji University and Mr. Chao Tao from Nanjing University, took part in the project. In order to realize the purpose of this project, our team carried out the activities below from April to December 2013.

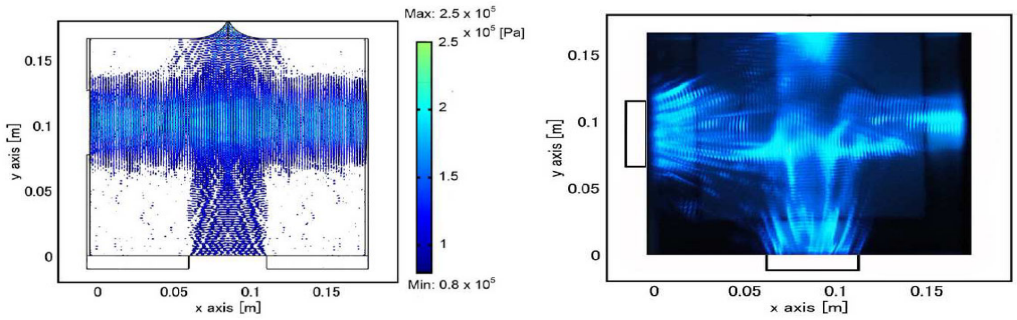
Step 1: On the basis of our literature review and the advantages of the respective institutions, the groups from the three universities put forward their own research proposals, which were then integrated in the design of a high-efficiency sonochemical reactor and its application. In June, the groups from Nagoya University and Tongji University came to Nanjing and visited Nanjing University, as shown in Fig. 1a. They visited the laboratory and participated in seminars held in Nanjing University. The three groups exchanged their ideas and refined the research content of the project, as shown in Fig. 2b. During our stay at Nanjing University, we also paid a visit to Prof. JunJie Zhu, the Nanjing University graduate school dean, and cooperation in graduate education between the three universities, such as joint training of doctoral candidates, was also discussed, as shown in Fig. 2a. The group from Nagoya University then went to Shanghai and visited the Institute of Acoustics at Tongji University, as shown in Fig. 2b.

Figures 1a and 1b

Figures 2a and 2b

Step 2: According to the research program, the ultrasonic reactor was designed at Nanjing University, and the ultrasonic transducer was fabricated at Tongji University. Then, the ultrasonic reactor was assembled and the experiments conducted at Nagoya University. The optimized ultrasonic reactor was used to degradate some dye wastewaters, and the results compared with those obtained using other type ultrasonic reactors. Figure 3 shows some cooperative research work: (a) the simulation reaction field and (b) a photograph of sonochemical luminescence in the optimized ultrasonic reactor. The simulation results were consistent with the experimental results.

A paper will be co-written by the graduate students from the three universities.



Figures 3a and 3b

Step 3: In November, the groups from Nanjing University and Tongji University visited Nagoya University. During their stay in Nagoya, the graduate students from the two groups visited the laboratory at Nagoya University and participated in the experimental work. The members from all three universities exchanged their ideas and optimized the methods and content of the experiments, as shown in Fig. 4a. The group members from Nanjing University and Tongji University also visited the museum for Nobel Prize winners at Nagoya University (see Fig. 4b).

Figure 4a and 4b

In conclusion, our team has mostly finished its tasks for this AC21 project and attained the final goals of the project. We have promoted understanding, cooperation and relationships between the graduate students from three universities in the form of inter-university visits, participating in seminars, group discussion, and the graduate students from all three universities studying and writing academic papers. On this basis, we can strengthen the cooperation in research and graduate education between the three universities. Meanwhile, this project will promote further understanding between the three universities and form a strong union of research in this field by integrating the advantages of the three universities, which may become a model of cooperation between AC21 member universities. Therefore, we would like to give special thanks to the AC21 Special Project Fund and Secretariat for their support.