Acoustic Cavitation in Flow reactors: Enabling Technology for modern Chemistry

PROGRAM AND BOOK OF ABSTRACTS

13th Meeting of the European Society of Sonochemistry

July 01–05, 2012
Lviv – Ukraine

OC-37: Acoustic Cavitation in Flow Reactors: Enabling Technology for modern Chemistry

Giancarlo Cravotto[1], Emanuela Calcio Gaudino[1], Davide Garella[1] and Pedro Cintas[2].

[1] *Dip.to di Scienza e Tecnologia del Farmaco, University of Torino, Via Giuria 9, 10125 Torino, Italy.*
[2] *Dpto. de Química Orgánica e Inorgánica, University of Extremadura, Avenida de Elvas s/n, E-06006 Badajoz, Spain.*

In recent years, chemistry in flowing systems has become more prominent as a method of carrying out chemical transformations, ranging in scale from microchemistry to kilogram-scale processes. Compared to classic batch US reactors, flow reactors stand out for their greater efficiency and flexibility as well as lower energy consumption. Herein we report ten years of investigation and design of sonochemical flow-reactors, applied to organic synthesis, the degradation of persistent organic pollutants and several manufacturing processes. Chemists are increasingly paying attention to combinations of enabling technologies with an eye to achieving the double goal of obtaining high efficiency and meeting the green criteria of energy savings and the absence of dangerous or harsh reagents. Flow-systems offer promising perspectives for automation and implementation which will move batch US-based chemistries to cleaner and more efficient continuous processes.

1. Lab-Scale Flow Reactors

Figure 1 shows loop-reactors enabling a continuous flow with a peristaltic pump that circulates the reacting mixture through the sonication compartments (20 and 300 kHz).

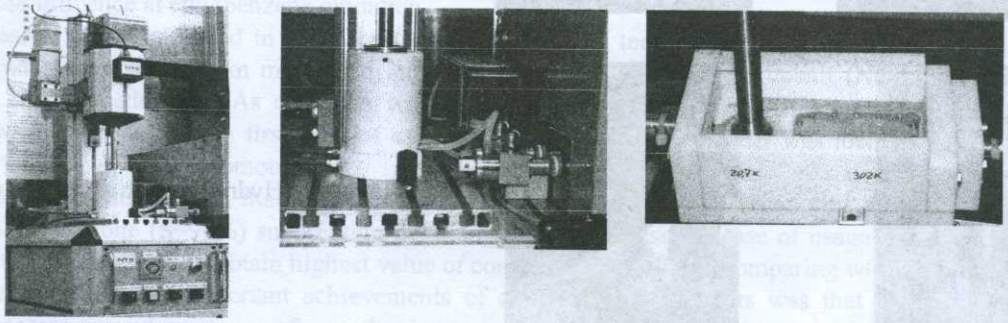

Figure 1: Lab-scale US flow reactors

In the last decade we have also developed high-power cavitating tubes that maximize cavitational effects. These titanium cylinders have been used as a support for coiled copper or PTFE tubing as depicted in Figure 2.

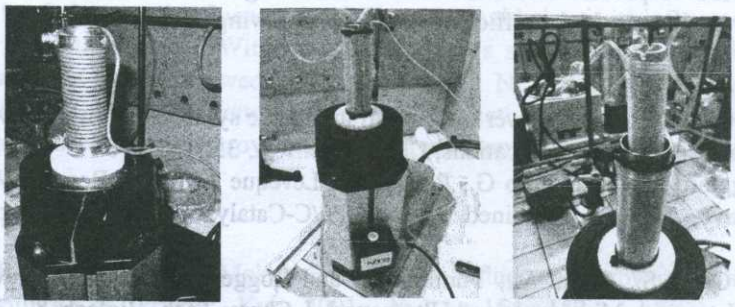

Figure 2: Sonochemical flow-mesoreactors

2. Lab to Pilot-Scale Flow-Reactors

The application of US to process intensification hinges on the development of large-scale multiple transducer sonochemical reactors operating in a continuous mode. Figure 3 shows the highly efficient sonotube available in two versions working at 20 and 35 kHz (volume: 70 and 700 cm^3 respectively) and a high density power. Figures 4 and 5

show US pilot reactors and a pilot system for hydrodynamic cavitation developed by the authors in collaboration with Danacamerini and E-Pic (Torino).

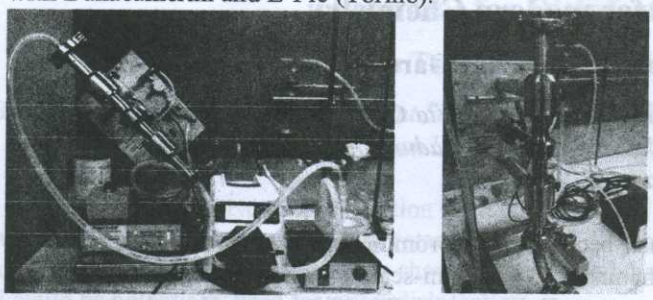

Figure 3: Flow sonication with Sonotube® (Synetude, Chambery, France).

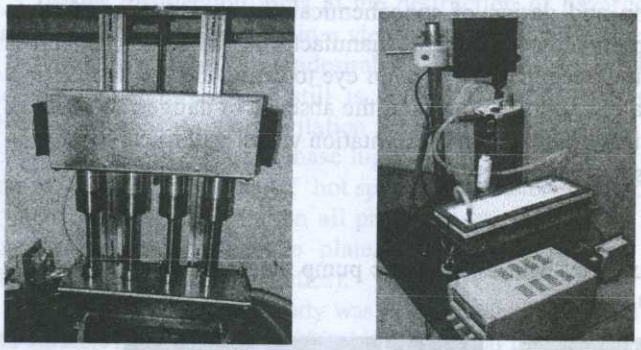

Figure 4: Two examples of pilot flow-reactors: a multi-horn and a multi-transducer emitting titanium plate.

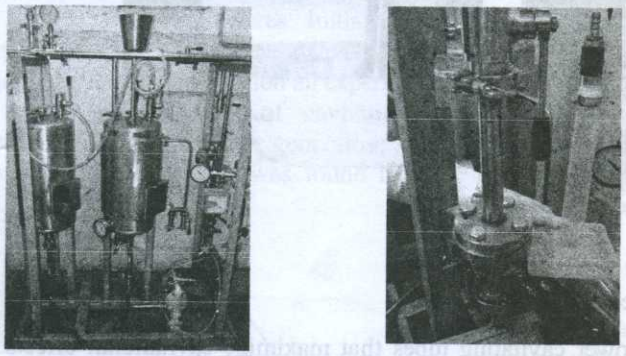

Figure 5: Hydrodynamic cavitation reactor

In summary, both research laboratories and the industrial sector are involved in the search for new technologies that may lead to process intensification. Our investigation confirmed the advantages of US flow-reactors due to the easier scaling up, higher efficiency and energy saving.

References

Cravotto G. and Cintas P., 2006, Power ultrasound in organic synthesis: moving cavitational chemistry from academia to innovative and large-scale applications, Chem. Soc. Rev. 35, 180-196.

Cravotto G., Beggiato M., Palmisano G., Penoni A., Lévêque J.M. and Bonrath W., 2005, High-Intensity Ultrasound and Microwave, Alone or Combined, Promote Pd/C-Catalyzed Aryl-Aryl Couplings, Tetrahedron Lett. 46, 2267-2271.

Cravotto G., Di Carlo S., Curini M., Tumiatti V. and Roggero C., 2007, A New Flow Reactor for the Treatment of Polluted Water with Microwave and Ultrasound, J. Chem. Tech. Biotech. 82, 205-208.

Bremner D., Di Carlo S., Chakinala A.G. and Cravotto G., 2008, Mineralisation of 2,4-dichlorophenoxyacetic acid by acoustic or hydrodynamic cavitation in conjunction with the Advanced Fenton Process, Ultrason. Sonochem. 15, 416-419.

Cintas P., Mantegna S., Calcio Gaudino E. and Cravotto, G., 2010, A new pilot flow-reactor for high-intensity ultrasound irradiation. Application to the synthesis of biodiesel, Ultrason. Sonochem. 17, 985-989.

Cravotto G., Bonrath W., Tagliapietra S., Speranza C., Calcio Gaudino E. and Barge A. 2010, Intensification of organic reactions with hybrid flow-reactors, Chem. Eng. & Processing: Process Intensification 49, 930-935.