Studies on the generation of nano droplets of immiscible liquids

Viorel Nastasa[1], T. Karapantsios[2], K. Samaras[2], E. Dafnopatidou[2] and M. L. Pascu[1]

[1]National Institutute for Laser, Plasma and Radiation Physics Bucharest, Romania
[2]Department of Chemistry, Aristolte University of Thessaloniki, Greece

The multiple resistances to treatment, developed by bacteria and malignant tumors require finding alternatives to the existing medicines and treatment procedures. One of them is strengthening the effects of cytostatics by modifying their molecular structures through exposure to laser radiation; the generation of micro/nano-droplets which contain medicines solutions is associated with it, the droplets being used as vectors to transport the medicines to targets.

The micro/nano-droplets may be produced by mixing of two immiscible solutions in particular conditions (high rotating speed and/or high pressure difference). For this we have studied the generation of emulsions of vitamin A diluted in sunflower oil and a solution of a surfactant Tween 80 in distilled water. The concentration of surfactant in water was typically $5*10^{-3}$ %. We have studied in a batch stirred tank system the dependence of the droplet dimensions in emulsion, function of the mixing rotation speed, agitation time and components ratio.

In order to study the dependence of droplets dimensions on the rotating speed we have varied the speed of the rotor for the same ratio oil/water. We have noticed that by increasing the speed we obtain droplets with smaller diameters. We have also varied the ratio between the oil component and the water volume in order to measure the dependence of droplets dimensions on it. The used ratios were: 10% - 50% oil in respectively 90% - 50% water. In each case the total volume of the mixture was 270 mL. At rotation speed of 600 rpm we have generated droplets with diameters between 20 μm and 500 μm noticing that 90% were in the 20 μm - 100 μm range.

In order to obtain droplets in nanometre range we have used an Ultra Turax T25 homogenizer providing up to 25000 rpm and a high pressure homogenizer APV with a $\Delta P = 800$ bar. The surfactant concentration in water was 0.32%. The droplet diameters were measured using a microscope type Axiostar and a Malvern light scattering instrument type Mastersizer Hydro 2000M. We have obtained droplets with diameters smaller than 100 nm; the diameters distribution exhibited a peak at 65 nm.

We report for the first time results on the measurements of the surface tension and contact angles of the micro-droplets containing solutions of BG1120, i.e. 4,6-bis(2-N,N-dimethyl-aminoethylthio)-10-methylpyrido[3,2-g]quinoline) and Doxorubicin, in ultra-pure water in the 10^{-3} M - 10^{-5} M concentration range. The measurements of surface tension and contact angles on hydrophobic and super hydrophobic surfaces show that the BG1120 and Doxorubicin molecules distribution in the droplets is and remains homogeneous in time. They show that the surface tension and the contact angles of ultra-pure water droplets and of droplets containing the medicines are practically the same, within the experimental errors. The resonant interaction between the micro-droplets of solutions of BG1120 and Doxorubicin in ultra-pure water, and the laser radiation was, for the first time, studied. In both cases the molecules exhibited significant modifications after exposure to laser radiation (the pH remained always neutral), which were evidenced by measuring the uv-vis absorption and LIF spectra. These modifications are obtained faster in micro-droplets than in the same solutions irradiated in bulk.