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In-Syringe Analysis with Magnetic Stirring

After reports of the usage of syringes in sample preparation protocols based on liquid-liquid extraction either in manual approaches or by autosampler devices, in 2012, Maya et al. demonstrated that also a syringe from a multisyringe flow injection analyzer can be used successfully as an extraction chamber for dispersive liquid-liquid microextraction (DLLME) [1].
Continuing this idea, I was working on fathoming the potentials of this approach including derivatization reactions [2-4]. In this time I came up with the idea of using a magnetic stirring bar inside the syringe and generating an external rotating magnetic field to force the its rotation. By this, an external mixing chamber was obsolete. This was an significant step forward in the development of in-syringe analysis or also denoted lab-in-syringe [5] and an important improvement of the systems' compactness and moreover versatility.

The potential for in-syringe magnetic stirring assisted DLLME was demonstrated [6] with significant improvements compared to a former work based on the same analytical procedure [5].
The outcome was a versatile analyzer system based on a simple Sequential Injection Analyzer but featuring a closed reaction chamber (the syringe), in which homogeneous mixing of as many as desired solutions of distinct volumes and viscosities could be carried out within seconds. This allows the straightforward miniaturization of manual standard protocols, in which large volumes of sample are mixed with small amounts of reagents.

Thanks to the syringe's size adaptability, procedures requiring several steps and addition of more reagents can be readily automated [7].
Higher stirring rates than in manual DLLME can be done due to the closed syringe, which allowed us to disperse efficiently water-immiscible solvents for automated DLLME without any other means.

In 2013, we developed an alternative operation mode to use the syringe pump upside down to use also solvents denser than water [8, 9] or to use the aqueous phase after extraction and backextraction of nitro-phenols with the lighter hexanol (18th ICFIA, Porto).

Recently, we demonstrated for the first time in-syringe vacuum- and stirring-assisted head-space microextraction including a simplified mode to achieve in-syringe stirring [10].
Pleasantly, more scientists have been and are using the in-syringe stirring technique for its potential for automated sample pretreatment and automation of analytical protocols is far from being explored.

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