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Development of laser ionization technique coupled with mass separation for environmental and medical applications: A case study of Copper

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A variety of laser-based applications has been developed since its invention in 1960s, among them is mass spectroscopy. A wavelength tunable laser radiation can selectively excite quantum transitions in atoms and molecules. A majority of laser spectroscopy methods are based on this resonance laser-matter interaction where resonant excitation and subsequent ionization of atoms is done using a suitable laser that is followed by a conventional spectrometry. It is often referred as Resonance Ionization Spectroscopy (RIS). Laser Resonance ionization is selective according to number of charge Z, while the application of an electromagnetic field ensures the separation of the isotopes according to their number of mass A. This combination allows to isolate an isotope with a high precision avoiding its isobars. SMILES project (Séparation en Masse couplée à l'Ionisation Laser pour des applications Environnementales et en Santé) initiated in SUBATECH lab aims at the development of a laser ionization device coupled with mass separation to quantify, purify and separate isotopes not only for environmental but also medical purposes. SMILES project is currently focused on copper element, as it is present in most anthropogenic sources of metals and assessing their isotopic composition can determine their contamination level in environment; also, 64Cu and 67Cu are rapidly emerging as potential diagnostic and therapeutic tools in nuclear medicine.
The main components that are involved in SMILES project include ionization system, beam focusing system and mass separator. The ionization can be achieved in a two-step process with one laser for desorption and another laser for ionisation of the excited atoms. The ionized beam can then be focused using a set of beam focusing lenses and deflectors. Finally, the mass separation can be achieved either by using an electromagnet or a Time-of-flight mass separator (TOF-MS). Both methods have proven to be efficient in literature. To study and optimize these parameters, SIMION software is often used [1,2,3]. It is a helpful tool in understanding the ion trajectories in an electromagnetic field. The performance of SIMION was studied and understood by performing several experiments before proceeding with the simulation. RISIKO mass separator (University of Mainz, Germany) and Time-of-flight mass separator (TOF-MS) were simulated, which will be helpful in configuring SMILES set-up.

Key words: RIMS, laser desorption, laser ionization, mass separator, SIMION

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Auteur principal: Mme KAMALAKANNAN, Keerthana (SUBATECH, GIP ARRONAX)

Co-auteurs: MICHEL, Nathalie (SUBATECH); Mme PISCITELLI, Anne (SUBATECH); M. SERVAGENT, Noel (SUBATECH); M. HADDAD, Ferid (GIP ARRONAX, SUBATECH)

Orateur: Mme KAMALAKANNAN, Keerthana (SUBATECH, GIP ARRONAX)

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