Contribution ID: **354** Type: **Verbal**

Investigation of astatine chemistry in solution

Tuesday, 13 May 2014 16:45 (15 minutes)

Astatine 211 is considered to be one of the most promising candidates for targeted alpha therapy (TAT)[1,2] and it is the subject of a wide research program in Nantes (France). A carrier molecule should transport At-211 to the cancer cells where alpha-particles emitted by the radionuclide would destroy the target. However binding astatine to cancer selective carrier molecules remains a difficult task. It is recognized that many of the basic chemical studies with astatine (At) have unfortunately been set aside, which currently hinders the development of radiotherapeutic agents [3] At-211 is produced in cyclotrons and all investigations were consequently derived from radiochemical studies at ultra-trace concentrations (typically smaller than 10-10mol.L-1). Therefore no spectroscopic tools can be used to assess At chemistry at the molecular level. These two points clearly limit the investigations of its chemistry, and consequently the development of efficient labelling protocols.
Based on these considerations, a research program has started to explore the fundamental properties of At using a multi-disciplinary approach combining radiochemistry, analytical chemistry and molecular modelling competences. The object of this contribution is to present the main advances obtained during the past 10 years as regards especially to the particular metallic character of astatine. Our methodology enabled to define a Pourbaix diagram (Eh/pH diagram) for At in non-complexing acidic aqueous medium. In addition to At- species, the experiments and quantum calculations highlighted the existence of two stable At+ and AtO+ cationic forms of astatine [4, 5]. This truly contrasts with others halogens. Recent results on the chemical reactivity of AtO+ demonstrate the potentiality to form both coordination and covalent bonds with organic and inorganic ligands [6-8]. The peculiarity of the AtO+ behaviour in water solvent will be also discussed [9,10].

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Session Classification: Radiopharmaceutical Chemistry, Labelled Compounds 1

Track Classification: Radiopharmaceutical Chemistry, Labelled Compounds