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Astatine: Halogen or Metal?

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The halogen family is generally assumed to stop at iodine. Does astatine, element 85, continue the vertical trend of the halogens, does it behave like a metal? Unfortunately, little is known of the basic chemistry of astatine: it is a rare (only short-lived isotopes can be produced) and “invisible” (the amount of produced ^{211}At requires working at ultra-trace concentrations) element. In the past decade, a program on astatine chemistry has been developed in Nantes in perspective to use ^{211}At for targeted alpha therapy [2]. The purpose of this presentation is to give an overview of the results obtained thanks to an original methodology combining experimental [3-5] and theoretical tools [6-8]

Astatine behaves as halogens. At^- was evidenced by ion-exchange chromatography [4] and electromobility [5] measurements. Most of the current labelling protocols are developed based on iodine chemistry and lead to the formation of of astato(hetero)aryl labelled compounds by electrophilic demetallation. An alternative approach with nucleophilic astatine based on arylidonium salts precursors was recently developed. A much higher reactivity of astatide than predicted was observed compared to iodide. Such discrepancy was rationalised by DFT calculations predicting differences in reaction pathways [9]. More recently, experiments have shown a first indirect indication of halogen bonding between AtI and Lewis bases, further supported by relativistic quantum mechanical calculations. AtI was found to be a stronger halogen-bond donor than I_2 [10].

Astatine behaves as metals. The range of existence of At^- is limited [11] with the presence of two At species at the oxidation states $+I$ (At^+) and $+III$ (AtO^+) [12] formed in more oxidizing conditions. Astatine cationic species can interact with both inorganic and organic ligands [11, 13-14] to form complexes. Interestingly, At^+ forms with I^- and Br^- the heaviest ternary trihalogen species, IAtBr^- in aqueous solution [15].

To conclude, astatine can be considered as a chameleon, as was highlighted by Visser in 1989 [16]. An important question may arise from this work: can we use the metal character of astatine to develop alternative labelling strategies in light of our recent results rationalizing the limit of the classical labelling protocol [17-18]?

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