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Fluorine, a key-element for the XXIst century: Uses of fluoride materials in modern technologies

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Inorganic fluorine based compounds can be found as components in many applications, including energy storage and conversion, microphotonics, fluorescent chemical sensors, solid state lasers, nonlinear optics, nuclear cycle, superhydrophobic coatings, etc. Most of these outstanding properties can be correlated to the exceptional electronic properties of the fluorine element, yielding almost unique types of bonding with the other elements. The strategic importance of inorganic fluoride materials will be illustrated by several examples taken from various scientific domains: 1) In the field of energy storage, fluorinated carbon nano-particles (F-CNPs) have been tested as active materials in primary lithium batteries. In secondary Li batteries, 3d-transition metal fluorides and oxyfluorides mostly based on iron and titanium have been proposed as electrodes. 2) Nanocrystalline metal fluorides derived from fluorite (CaF_2) or tysonite (LaF_3) types exhibit high F- anionic conductivity that can be used as solid electrolytes in F- ion based all solid state batteries. 3) Upconversion and luminescent phenomena in nano fluorides based on rare earth metals. 4) Transparent fluoride ceramics which may challenge single crystals or glasses for solid state lasers applications. 5) Among transparent conductive oxides and oxide-fluorides, F-doped SnO_2 exhibits rather good transparency in the visible range and high infrared absorption associated to its conductivity due to n-type charge carriers. 6) Perovskite related solid state fluorides based on d-transition metals exhibit a huge variety of structural and magnetic behaviors. Layered $BaMF_4$ and iron fluorides (TTB- $K_3Fe_5F_{15}$) are important families of multiferroics, in which magnetism and ferroelectricity coexist. 7) Intercalation of fluorine in several networks of oxides allows tuning the transition metal oxidation state. Superconductivity was created in F-doped cuprate systems La_2CuO_4 and Sr_2CuO_3 using low-temperature fluorination by F_2 gas, or in F-doped oxypnictide $LnFePnO_{1-x}F_x$ (T_c ~58 K). Finally, functionalization processes using various fluorination treatments yield nanosized materials, high surface area fluorides, or switchable hydrophobic/hydrophilic coatings.

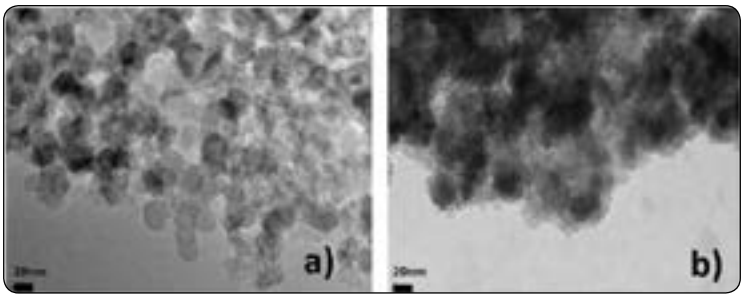

Figure 1: The nanosize of F-CNPs obtained from nano-carbons prepared in molten carbonates (b), is not changed after low-temperature F_2 fluorination (a)

Recent Publications

1. Progress in fluorine science (2016) Vol. 1 – Photonic & electronic properties of fluoride materials. A Tressaud and K Poeppelmeier Eds. Elsevier, USA.
2. Vol. 2 – New fluorinated carbons: Fundamentals and applications (2016) O Boltalina and T Nakajima Eds. Elsevier, USA.
3. Vol. 3 – Modern synthesis processes and reactivity of fluorinated compounds (2017) H Groult, F Leroux and A Tressaud Eds. Elsevier, USA. ISBN: 9780128037904.
4. Vol. 4 – Fluorine in life sciences: Pharmaceuticals, medicinal diagnostics, and agrochemicals (2018) G Haufe and F Leroux Eds. Elsevier, USA. ISBN: 9780128127339.
5. Functionalized inorganic fluorides (2010) A Tressaud Ed. Wiley. ISBN: 978-0-470-74050-7.

Biography

Alain Tressaud is Emeritus Research Director at ICMCB-CNRS, Bordeaux University. He is the President of the European Academy of Sciences (Brussels) and member of several European Academies. He founded and chaired until 2008 the French CNRS Network on Fluorine Chemistry. Among the awards he received, the Atomic Centre Agency (CEA) Award of French Academy of Sciences (2008), ACS Fluorine Award (2011) and Moissan Prize (2013) can be quoted. His scientific interest covers synthetic fluorine chemistry, physical-chemical characterizations, applications in materials sciences, solid state chemistry. His works also deal with surface modification of materials and intercalation chemistry. His scientific production includes more than 360 papers in international journals, 20 chapters' contributions in books and 12 internationalized patents. In addition, he edited 10 books, including the Editor-in-Chief responsibility of the book series *"Advances in Fluorine Science"* Elsevier (2006), *"Progress in Fluorine Science",* Elsevier (2015), *"Progress in Science, Progress in Society",* Springer-Nature, (2017).

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