X4C is a recently created spin-off company from Brussels University (ULB) that wants to become a leader in innovative surface coating solutions for high-end applications (diagnostic, (bio)electronic, medical devices and optic).

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The X4C solution

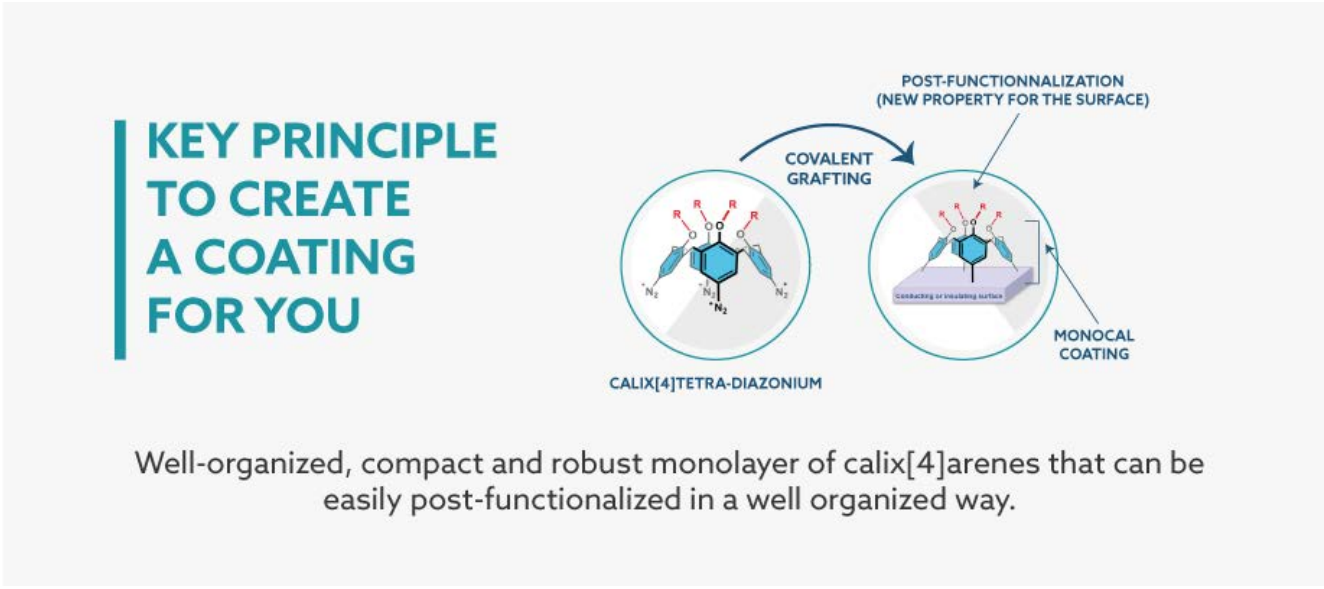
The new coating technology ("***X4C Technology***") was developped by A. Mattiuzzi (CEO of X4C) during her thesis at ULB. *X4C Technology* consists of the covalent grafting of calix[4]arene-tetradiazoniums that can bear either:

- hydrophobic groups (e.g. alkyl or fluoroalkyl);
- hydropihilic groups (e.g. OEG, PEG or COOH);
- functional groups (e.g. COOH, COCl, NHS-activated acid, alkyne, azide, etc.).

X4C Technology can be applied on any surface (conducting, semiconducting or insulating surfaces) and provides a well-organized, compact and robust monolayer of calix[4]arenes ("***Monocal Coating***").

Monocal Coating can therefore generate hydrophobic/hydrophilic surfaces or permit a post-modification with various molecules, biomolecules (carbohydrates, DNA, proteins, etc.), nanoparticles or oligomers. Post-modification opens the door to new properties for the surfaces: sensing, reduction of non-specific adsorption of protein, antibiofilm, anti-fouling, etc..

In addition, different chemical or biochemical entities can be simulaneously introduced in a controlled way onto the surface, leading to a multifunctional surface that can display different properties at the same time.



Well-organized, compact and robust monolayer of calix[4]arenes that can be easily post-modified in a well organized way.

Types of surfaces and resulting properties

Various conducting, semi-conducting and insulating surfaces have been modified so far:

- **Conducting surfaces**: gold, carbon (glassy carbon and PPF), carbon nanotubes, stainless steel, platinum, iron, nickel, chromium, gold CPB
- **Semi-conducting surfaces**: germanium
- **Insulating surfaces**: polypropylene, polystyrene, polyethylene terephthalate, polymer Si-organic, glass
- **Nanoparticles**: gold NPs, iron oxide NPs, platinum NPs

Various properties such as hydrophobicity, reduction of platelet aggregation, reduction of protein adsorption, anti-biofilm, pH and chemical stability have been brought to these surfaces.

Stability of *Monocal coating*

Depending on the targeted application, stability towards UV, chemical agents, temperature and abrasion was evaluated. For example:

- Stability of modified stainless steel surfaces towards abrasion;
- Stability towards chemical agents (NaOH 0.1M and HCl 0.5M) of germanium surfaces, gold surfaces and gold nanoparticles modified by the *Monocal technology*.

All the tests that have been performed so far have demonstrated a high stability of the coating. Moreover, its properties are maintained after abrasive or chemical treatments. Temperature stability of modified gold nanoparticles was also determined to be > to 350°C. Accurate aging studies were not realized so far; however, all the different modified surfaces were kept several weeks without any modification of their properties.

Collaboration with industrial partner

As explained previously, X4C develops a unique methodology, i.e. *Monocal Coating*, in the field of surface modification. This patented methodology can be applied to almost any surface and allows the grafting of a well-controlled, compact and robust organic monolayer of calixarenes that can be easily post-modified. *Monocal Coating* can bring various properties in a well-organized way to a substrate while preventing the loss of its inherent properties (e.g transparency, conductivity, etc.).

This breakthrough technology pushes the boundaries of knowledge and innovation in the field of surface modification and opens exciting perspectives for new high-end applications in different sectors such as optic, (bio)electronic, medical devices, diagnostic, etc.

In terms of offering, X4C proposes a 3-step approach:

- feasibility study with a standard *Monocal Coating* on the surfaces chosen by the partner;
- development of specific *Monocal Coating* on these surfaces for the application of the partner;
- licence rights to further use the technology.

Patent and publications

1- "*Materials Coated with Calixarenes*" Mattiuzzi, A.; Jabin, I.; Reinaud, O.; Hapiot, P.; Lagrost, C. **Patent WO2013152967**, Apr. 2012.

2- « *Electrografting of calix[4]arenediazonium salts to form versatile robust platforms for spatially controlled surface functionalization* » A. Mattiuzzi, I. Jabin, C. Mangeney, C. Roux, O. Reinaud, L. Santos, J.-F. Bergamini, P. Hapiot and C. Lagrost **Nature Commun.**, 2012, **3**, 1130-1137.

3- "*One-Pot Electrografting of Mixed Mono-Layers with Controlled Composition*" Santos, L.; Mattiuzzi, A.; Jabin, I.; Vandencasteele, N.; Reniers, F.; Reinaud, O.; Hapiot, P.; Lhenry, S.; Leroux, Y.; Lagrost, C. **J. Phys. Chem. C**, 2014, **118**, 15919-15928.

4- "*Extremely robust and post-functionalizable gold nanoparticles coated with calix[4]arenes via metal–carbon bonds*" Troian-Gautier, L.; Valkenier, H.; Mattiuzzi, A.; Jabin, I.; Van den Brande, N.; Van Mele, B.; Hubert, J.; Reniers, F.; Bruylants, G.; Lagrost, C.; Leroux, Y. **Chem. Commun**., 2016, **52**, 10493-10496.

5-"*Controlled Modification of Polymer Surfaces Through Grafting of Calix[4]arene-Tetradiazoate Salts*" Troian-Gautier, L.; Martinez-Tong, D.; Hubert, J.; Reniers, F.; Sferrazza, M.; Mattiuzzi, A.; Lagrost, C.; Jabin, I. **J. Phys. Chem. C**, 2016, **120**, 22936-22945.

6- "*Immobilization of monolayers incorporating Cu funnel complexes onto gold electrodes. Application to the selective electrochemical recognition of primary alkylamines in water*" De Leener, G.; Evoung-Evoung, F.; Lascaux, A.; Mertens, J.; Porras-Gutierrez, A. G.; Le Poul, N.; Lagrost, C.; Over, D.; Leroux, Y. R.; Reniers, F.; Hapiot, P.; Le Mest, Y.; Jabin, I.; Reinaud, O. **J. Am. Chem. Soc.,** 2016, **138**, 12841-12853.