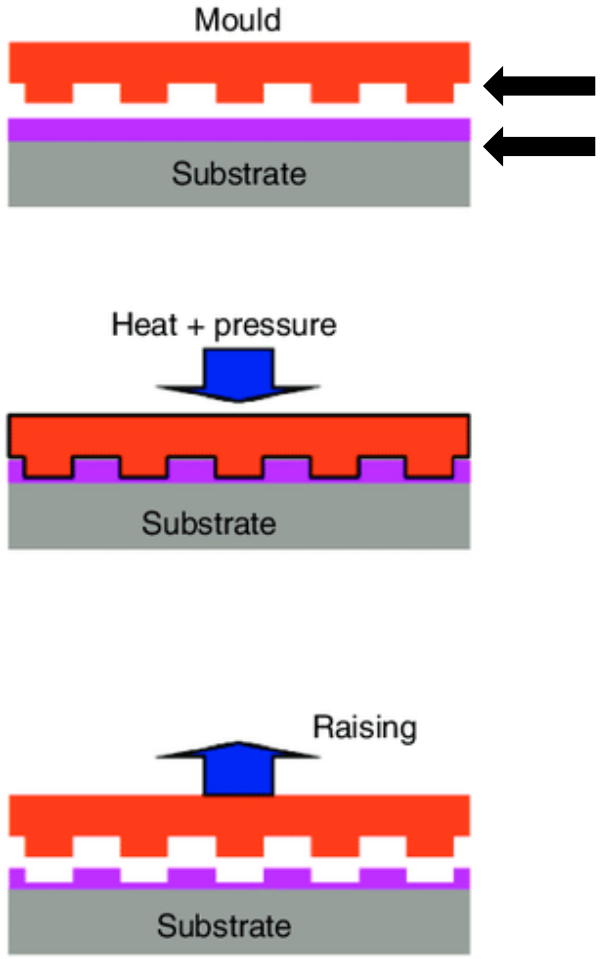
Institut des Nanotechnologies de Lyon UMR 5270

Surface modifications of oxides using the silanisation reaction

T. Géhin, C. Yeromonahos, V. Monnier, V. Dugas, M. Phaner Goutorbe, E. Laurenceau, J-P. Cloarec et I. Nabeth et Y. Chevolot

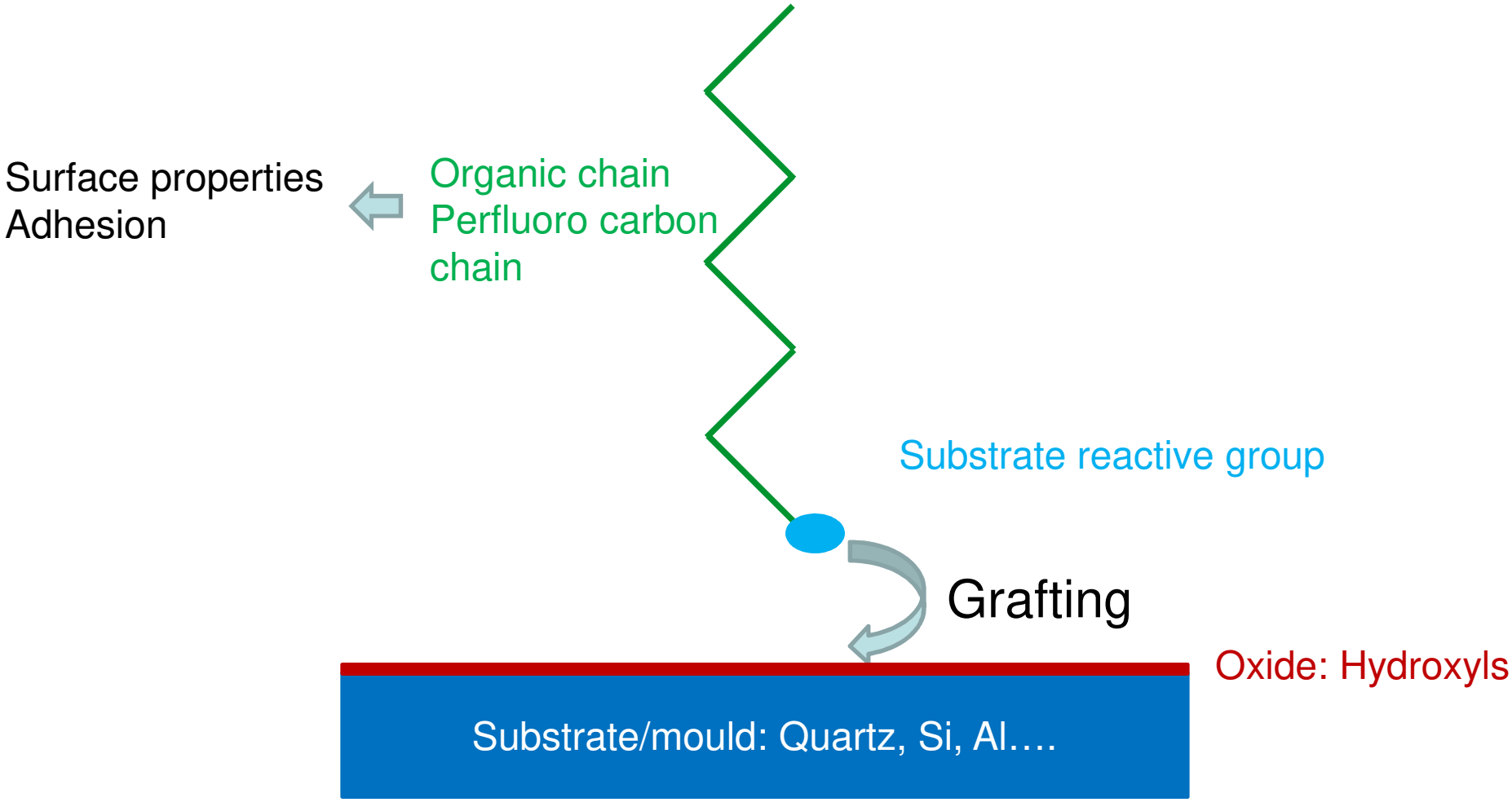
Introduction



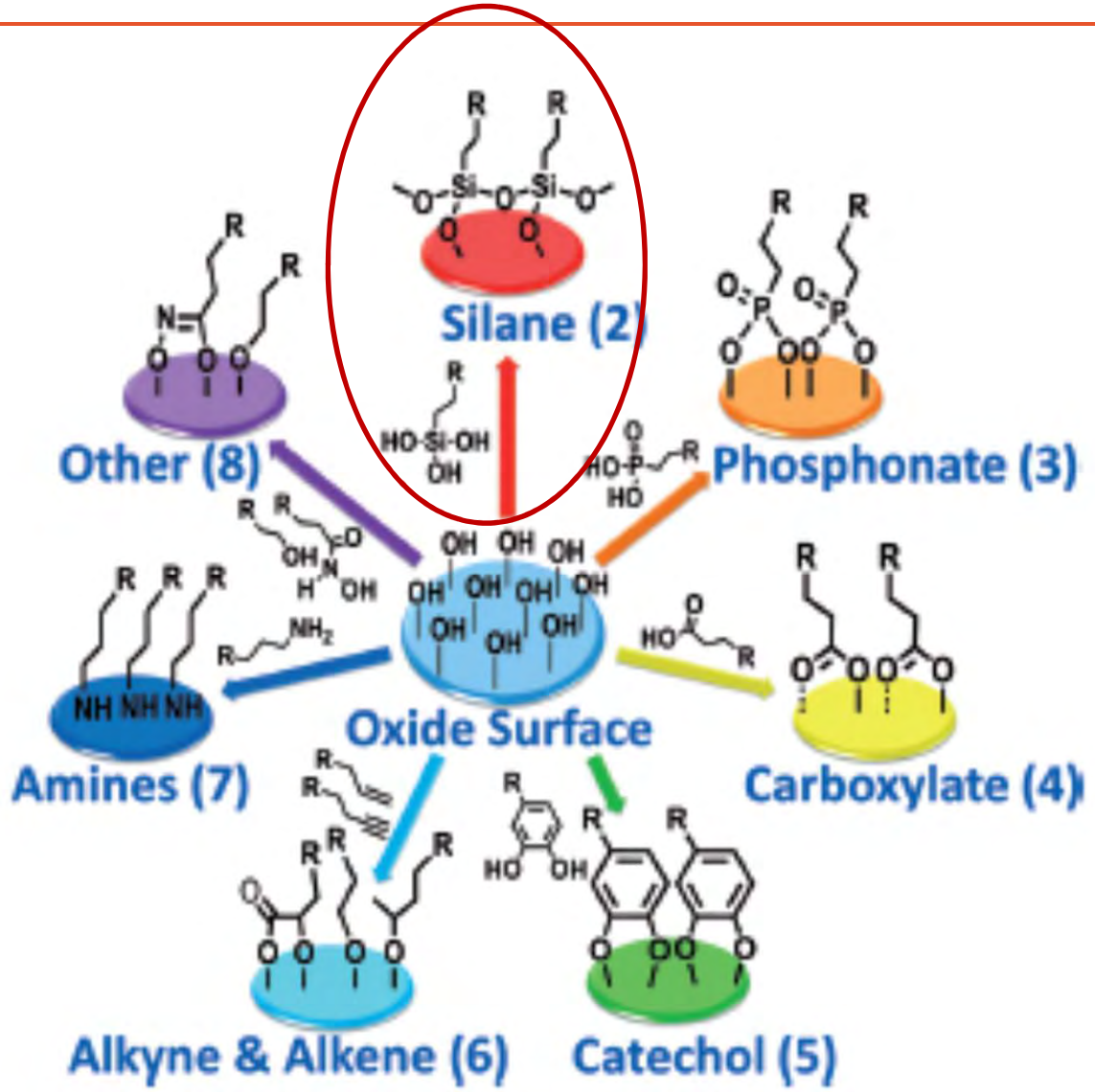
Adjust surface properties:
Adhesion, wettability…
-Self assembled monolayer

Y.G. Bi ***et al,*** Nanophotonics, 7 (2017)

Coupling agents



Oxide reactive groups



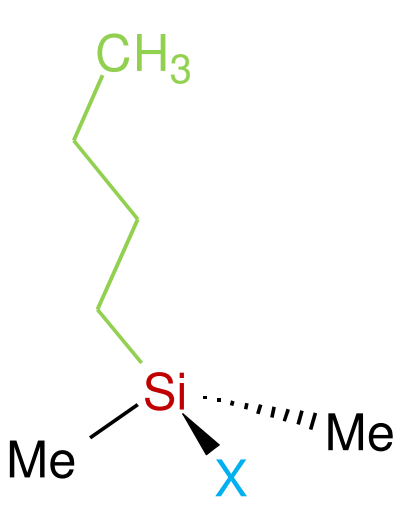
Pujari et al, Angew. Chem. Int. Ed. 2014, 53, 6322 – 635

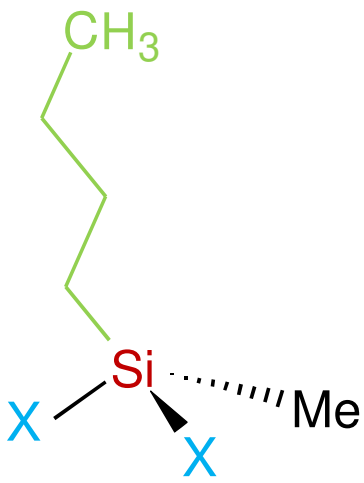
Organo-silanes

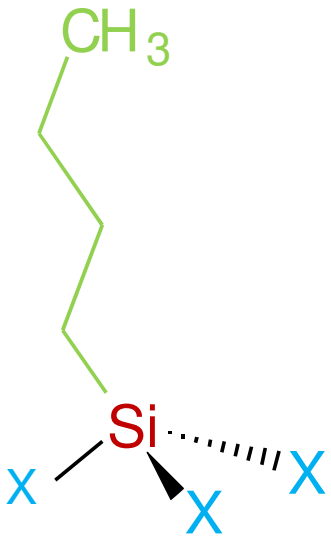
Organic chain

Hydrolysable group

$$(R)_z\text{-}SiX_{(4-z)}$$







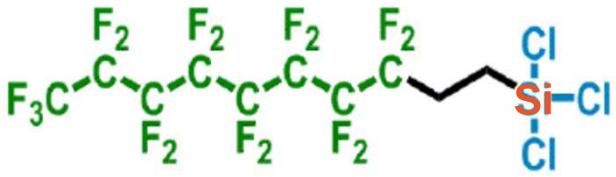
Monofonctionnal < Difonctionnal < Trifonctionnal

Organo-silanes

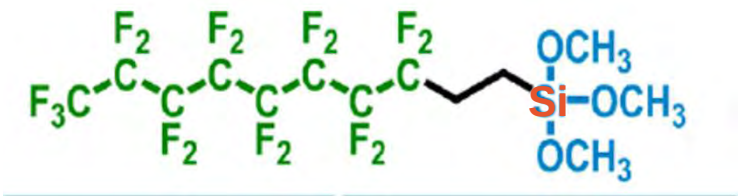
Hydrolysable group

Hydrocarbon chain

$$(R)_z\text{-}SiX_{(4-z)}$$



Chlorosilane



Alcoxysilane:
Methoxysilane: CH_3O
Ethoxy silane: CH_3CH_2O

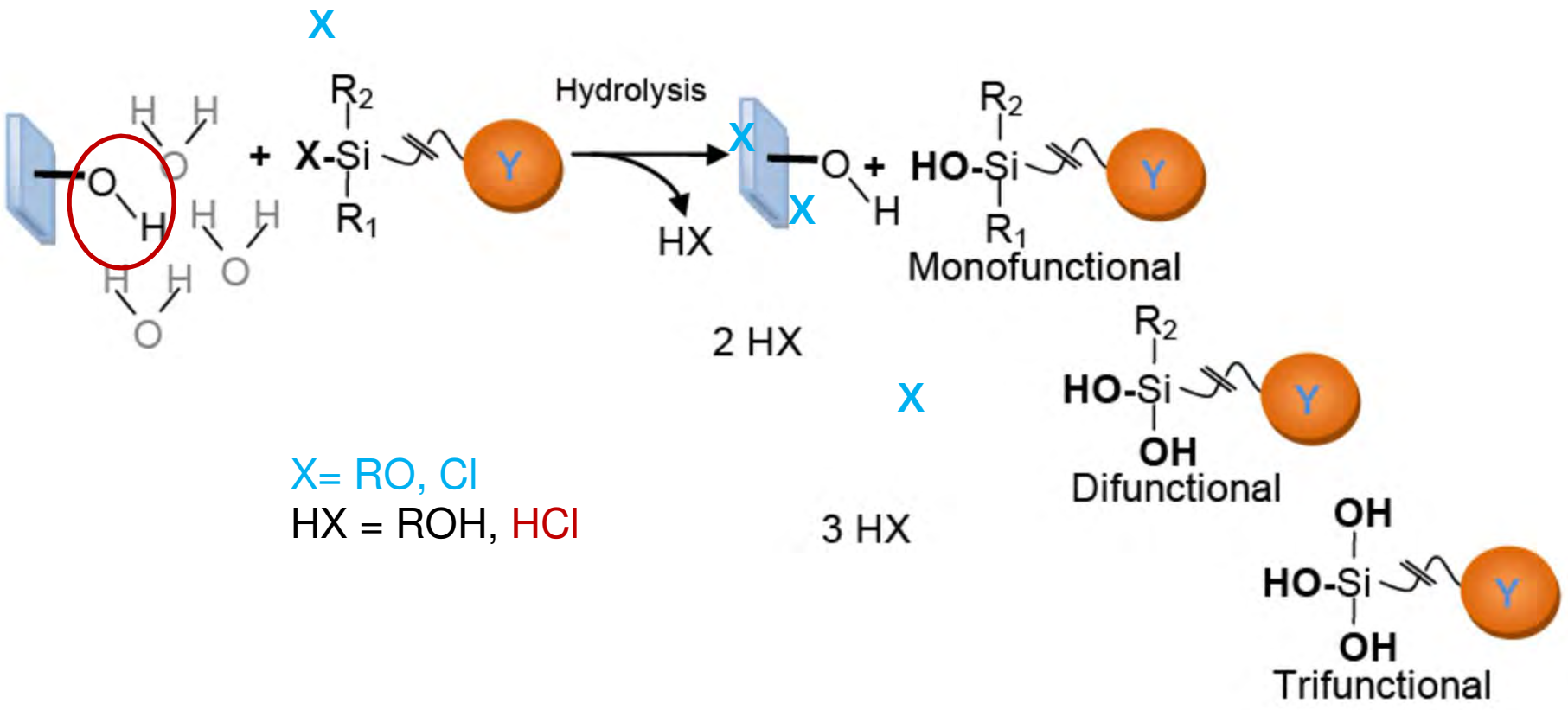
$$EtO < MeO < Cl$$

Silanisation reaction: step 1

- Formation Silyl ether: Si-O-M
- 2 mechanisms:
  - Anhydrous conditions: one step reaction but 300-400°C or base catalyst
  - **Water: 2 step reaction**

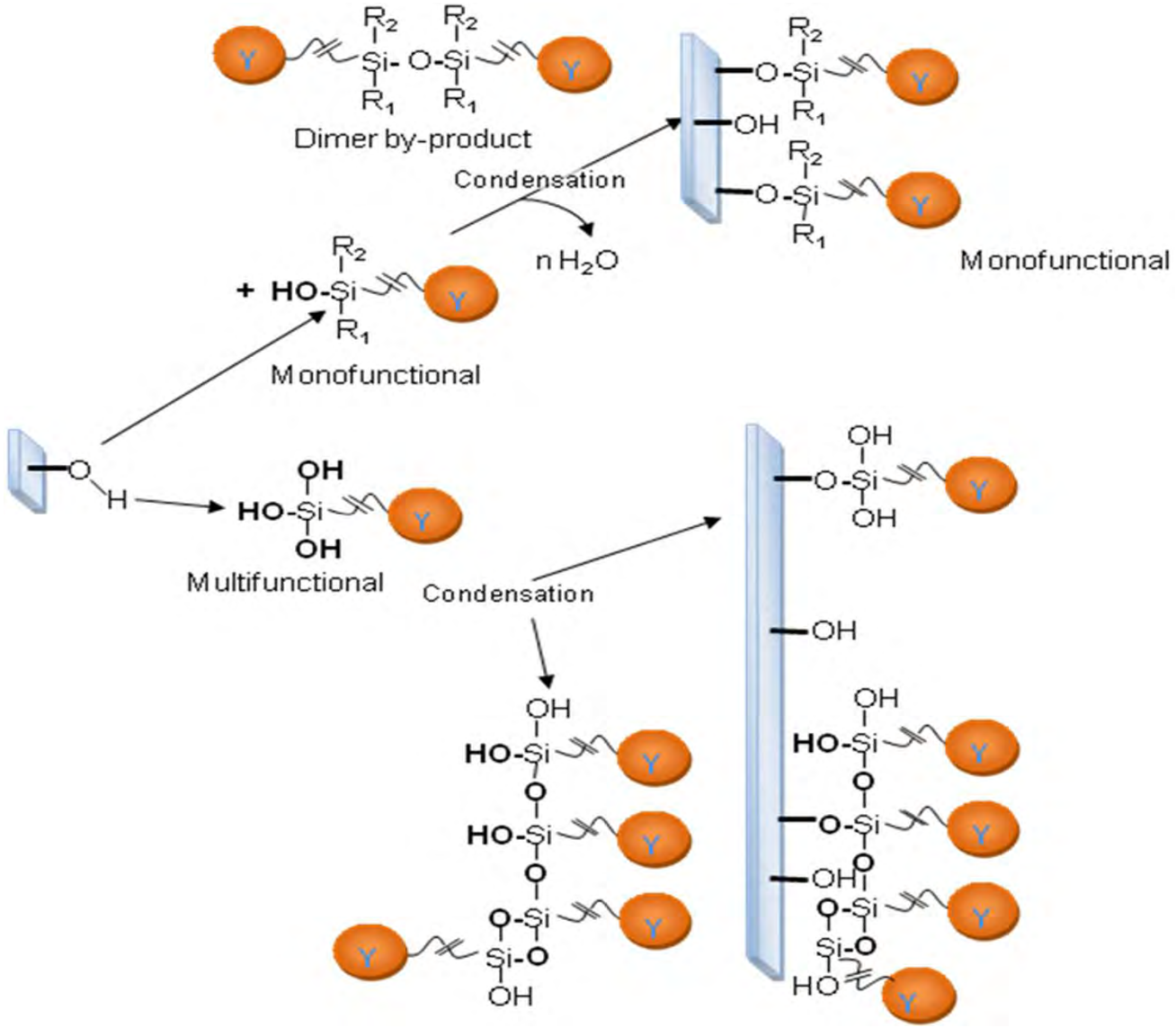
Dugas ***et al***, Use of Organosilanes in Biosensors, Novascience, 2010

Silanisation reaction: step 1



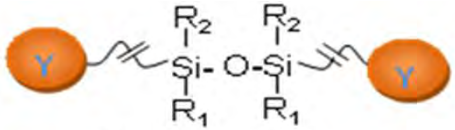
Dugas ***et al***, Use of Organosilanes in Biosensors, Novascience, 2010

Silanisation reaction: step 2



Dugas ***et al***, Use of Organosilanes in Biosensors, Novascience, 2010

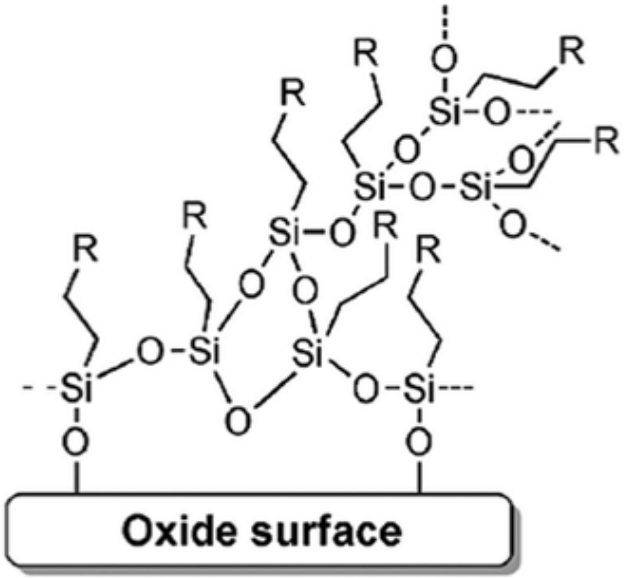
Water content and polymerisation



Dimer by-product

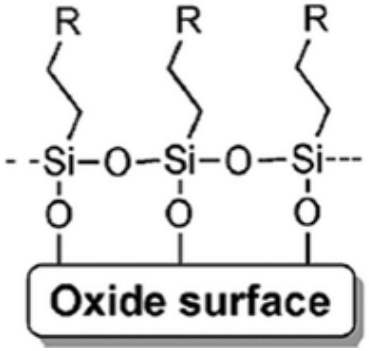
Monfunctionnal

vs multifunctionnal



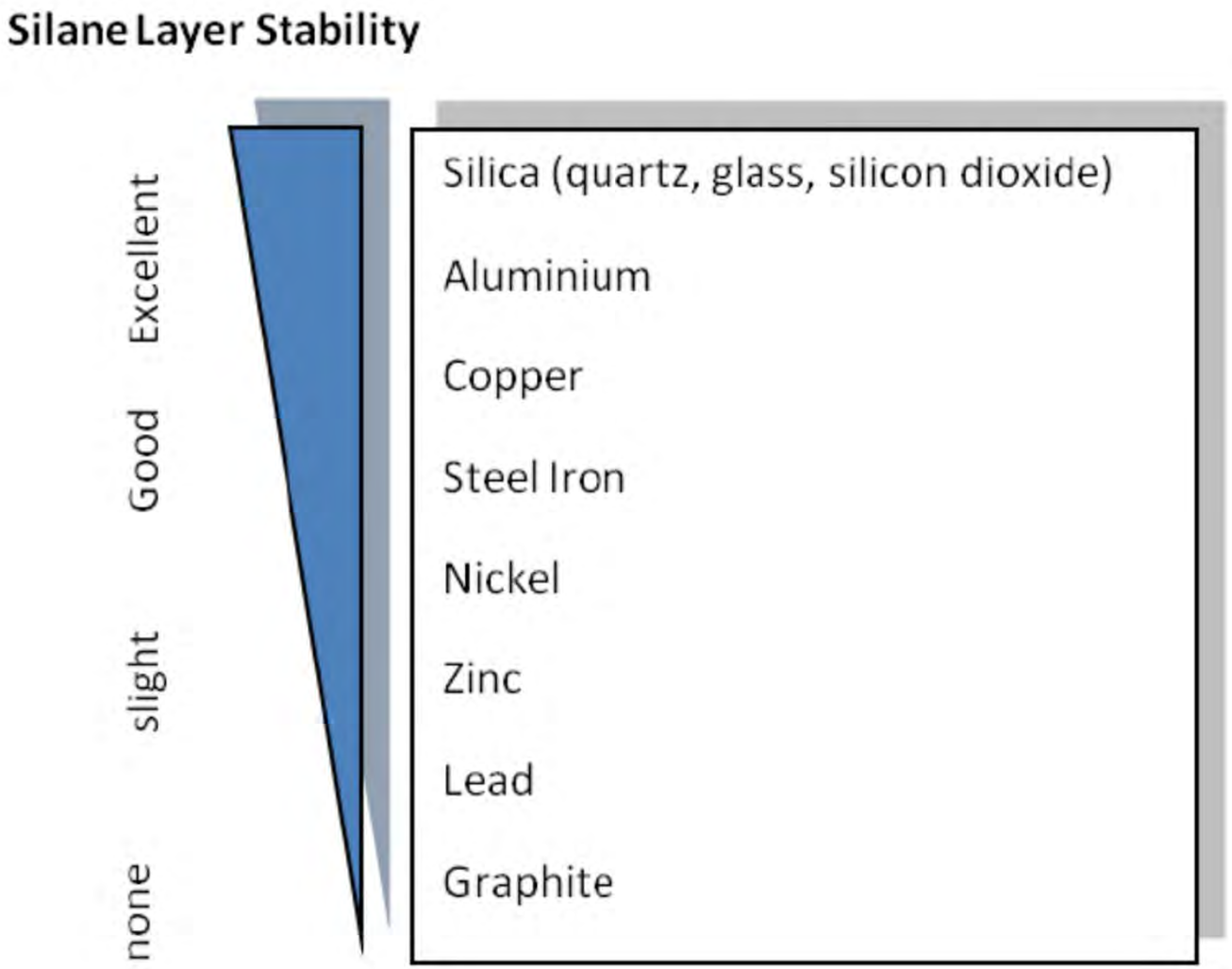
high water content
high concentration

proper water content,
ideal solvent
ideal concentration



Pujari et al Angew. Chem. Int. Ed. 2014, 6322

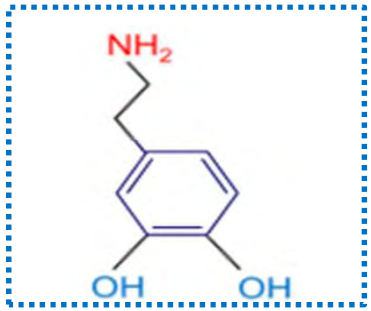
Stability


Silane Layer Stability
Excellent
Good
slight
none
Silica (quartz, glass, silicon dioxide)
Aluminium
Copper
Steel Iron
Nickel
Zinc
Lead
Graphite

Phosphonic acids

DA

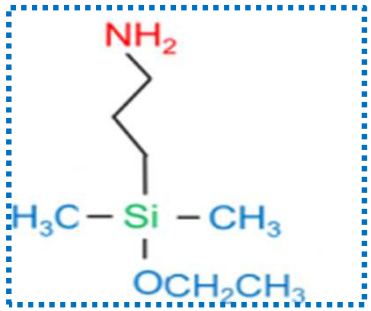
Catechol



TiW

APDMES

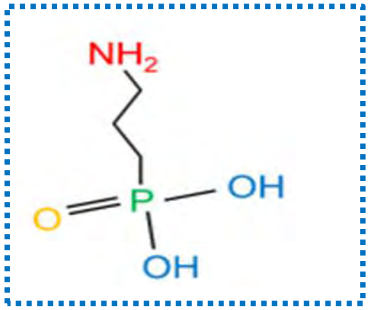
Silane



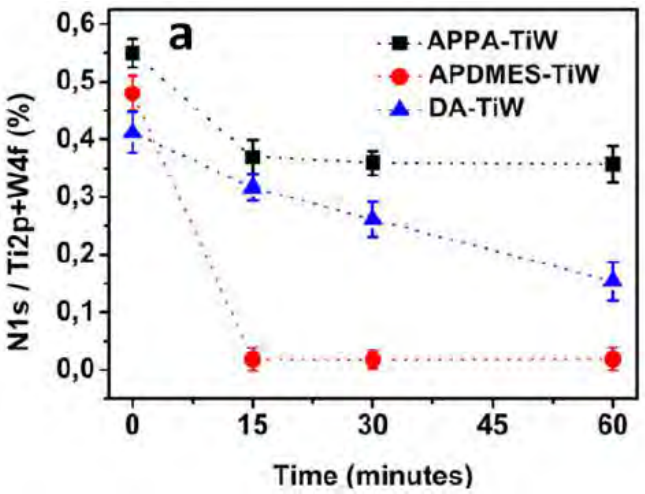
TiW

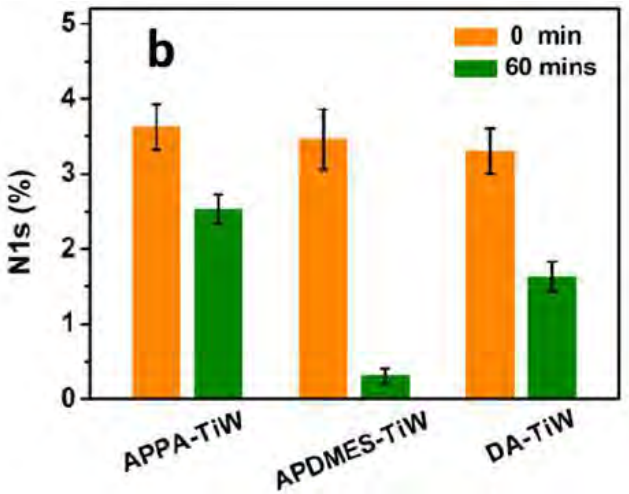
APPA

Phosphonic acid



TiW





Zhang et al, Langmuir 2019, 35, 29, 9554–9563

UE and per- and polyfluoroalkyl substances (PFAS)

https://fr.wikipedia.org/wiki/Substances_per-_et_polyfluoroalkyl%C3%A9es
https://echa.europa.eu/fr/-/echa-publishes-pfas-restriction-proposal

Conclusions

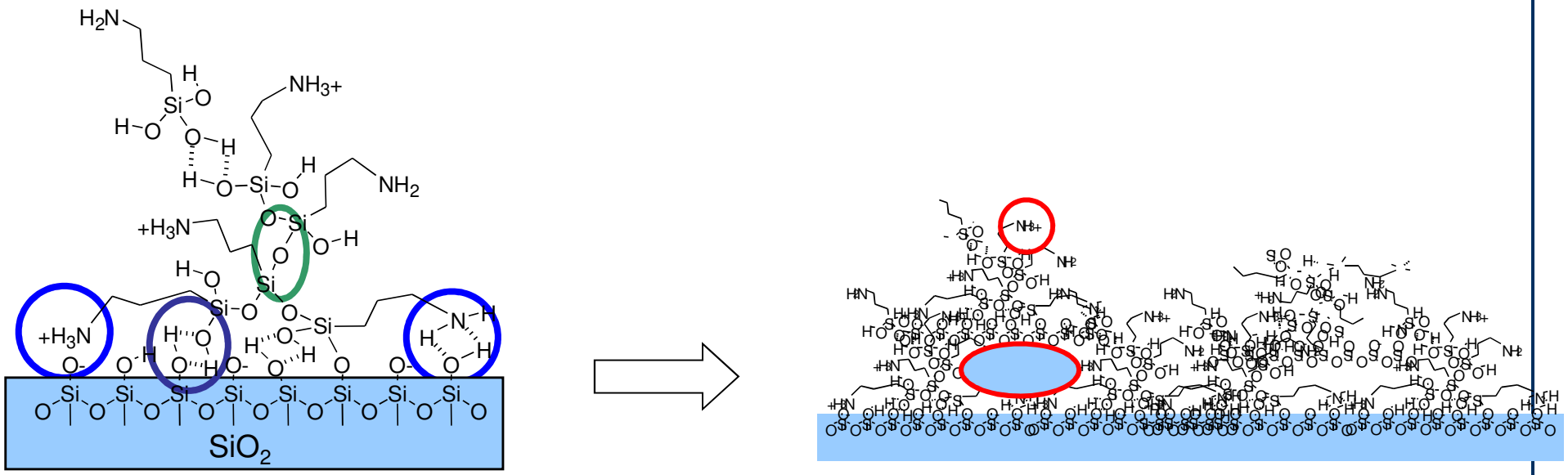
- Surface hydroxyls,
- Chlorosilane: corrosion,
- Layer stability:
  - Polymerisation,
  - Materials,
- Layer reproducibility:
  - Mono vs mutifonctionnal,
  - Water content,
- Phosphonic acids,
- Restriction use of PFAS to come

Remerciements

nanolyon

Thank you for your attention

Polymérisation non contrôlée



Stabilité couche silane difonctionnel > trifonctionnel

M. Zelsmann ***et al***, J. Vac. Sci. Technol. B , 2009, p. 2873