# Design of nanocatalysts following molecular chemistry principles

**Dr. Karine Philippot**
Directrice de recherche au CNRS
Laboratoire de Chimie de Coordination du CNRS (LCC-CNRS), Toulouse, France

Due to their singular properties and potential applications in various fields, considerable effort is being devoted to the design of metal-based nanomaterials. The "Metal Nanoparticle Engineering" team at LCC-CNRS (Toulouse, France) has developed an effective toolkit for the synthesis of controlled metal nanoparticles using concepts from molecular chemistry. This approach is based on the hydrogenation of organometallic or metallo-organic complexes under mild conditions (ambient temperature; 3 bar $H_2$) in the presence of ligands as stabilising agents.[1] This approach makes it possible to obtain small nanoparticles (<10 nm) with controlled composition, either monometallic or bimetallic (alloy, core-shell, surface-decorated). These nanoparticles can be deposited on a support by simple impregnation or by direct synthesis in the presence of the chosen support (polymers, ionic liquids, silica, alumina, carbonaceous materials, etc.). These metal nanoparticle systems are suitable models for fundamental research. They find applications in various fields such as catalysis.[2,3] Non exhaustive examples concern biomass valorization[4], hydrogenation catalysis[4-6] including reduction of $CO_2$,[7] or electrocatalytic[8-11] or photocatalytic[12-13] water splitting process.

**References**

1 C. Amiens, D. Ciuculescu-Pradines, K. Philippot, *Coord. Chem. Rev.,* **2016,** 38, 409-432.
2 M. R. Axet, K. Philippot, Chem. Rev 2020, *Chem. Rev*. **2020**, 120, 2, 1085-1145.
3 Nanoparticles in Catalysis: Advances in Synthesis and Applications, Wiley-VCH, K. Philippot & A. Roucoux (Eds.), **2021.**
4 M. Cardona, P. Lecante, C. Dinoi, I. del Rosal, R. Poteau, K. Philippot, M. Rosa Axet, *Green Chemistry,* **2021**, 23, 8480-8500.
5 C. J Abou-Fayssal, C. Fliedel, R. Poli, A. Riisager, K. Philippot, E. Manoury, *Materials Today Chemistry*, **2023**, 34, 101752 (https://doi.org/10.1016/j.mtchem.2023.101752).
6 D. Krishnan, L. Schill, M. R. Axet, K. Philippot, A. Riisager, *ChemCatChem* **2024**,16(4): e20230144.
7 X.-P. Fu, L. Peres, J. Esvan, C. Amiens, K. Philippot, N. Yan, *Nanoscale,* **2021***, 13,* 8931-8939.
8 J. Creus, S. Drouet, S. Suriñach, P. Lecante, V. Collière, R. Poteau, K. Philippot, J.García-Antón, X. Sala, *ACS Catalysis.,* **2018**, 8, 11094-11102.

9 L. Mallón, J. Navarro-Ruiz, C. Cerezo-Navarrete, N. Romero, I. del Rosal, J. García-Antón, R. Bofill, L. M. Martínez-Prieto, K. Philippot, R. Poteau, X. Sala, *ACS Applied Materials & Interfaces* **2025**, 17(4), 6198-6210.

10 Nanoscale NiCu electrocatalyst for the hydrogen evolution reaction, T. Straistari, N. Romero, J. Esvan, M. Gil Sepulcre, C. Amiens, O. Rüdiger, S. Debeer, S. Cavaliere, K. Philippot, *Nanoscale* **2025**, 17, 17592-17603.

11 Regulating NiFeOOH oxidation states through ruthenium incorporation, L. Mallón,1, L. Peres, N. Rivas, A. Garzón Manjón, C. Scheu, M. Gil-Sepulcre, O. Rüdiger, S. DeBeer, N. Romero, J. Esvan, J. García-Antón, L. Rodríguez-Santiago, X. Solans-Monfort, R. Bofill, K. Philippot, L. Francàs, X. Sala, *J. Mater. Chem. A*, **2026**, *in press*.

12 N. Romero, F. Sabuzi, M. Forchetta, M. Natali, R. Signorini, R. Bofill, L. Francàs, M. Gil-Sepulcre, O. Rüdiger, S. DeBeer, J. García-Antón, K. Philippot, P. Galloni, A. Sartorel, X. Sala, *Green Chemistry* **2025**, 27, 4352-4368.

13 Dyadic Ru-based Nanomaterials for Visible Light-driven Photocatalytic Hydrogen Evolution, G. Martí, M. Aliqué, I. López, L. Francàs, R. Bofill, O. Schott, G. S. Hanan, N. Romero, K. Philippot, A. Llobet, M. Natali, J. García-Antón, X. Sala, *Applied Surface Science*, **2026**, 716, 164621.

**Organometallic synthesis of metal nanoparticles and applications in catalysis**

***Dr. Karine Philippot***
CNRS Director of Research
Laboratory of Coordination Chemistry of Toulouse, CNRS (LCC-CNRS)
France

***Abstract***

As a consequence of their attractive properties and potential application in various domains, many efforts are devoted to access well-defined metal-based nanomaterials. The "Engineering of Metal Nanoparticles" team at LCC-CNRS (Toulouse, France), has been developing an efficient toolbox for the synthesis of controlled metal nanoparticles by using the concepts of molecular chemistry, i.e. by hydrogenation of organometallic/metal organic complexes in mild conditions (r.t; 3 bar H2) in the presence of ligands as stbilizers.[1] This approach leads to nanoparticles of controlled size and composition, either monometallic or bimetallic (alloy, core-shell, surface-decorated) and also supported (on silica or carbon supports among others). These systems are suitable models for fundamental investigations, and beyond, in fields such as catalysis[2,3] including the upgrade of biomass,[4] or energy, for instance for the production of hydrogen through the water-splitting process,[5] or the valorization of $CO_2$.[6] This will be illustrated by recent examples.

References

1 C. Amiens, D. Ciuculescu-Pradines, K. Philippot, *Coord. Chem. Rev.,* **2016,** 38, 409-432.
2 M. R. Axet, Chem. Rev 2020, *Chem. Rev*. 2020, 120, 2, 1085-1145.
3 Nanoparticles in Catalysis: Advances in Synthesis and Applications, Wiley-VCH, K. Philippot & A. Roucoux (Eds.), **2021.**
4 M. Cardona, P. Lecante, C. Dinoi, I. del Rosal, R. Poteau, K. Philippot, M. Rosa Axet, *Green Chemistry,* **2021**, 23, 8480-8500.
5 J. Creus, S. Drouet, S. Suriñach, P. Lecante, V. Collière, R. Poteau, K. Philippot, J.García-Antón, X. Sala, *ACS Catalysis.,* **2018**, 8, 11094-11102.
6 X.-P. Fu, L. Peres, J. Esvan, C. Amiens, K. Philippot, N. Yan, *Nanoscale,* **2021***, 13,* 8931-8939.

***Biography***

Dr Karine Philippot received her PhD degree in Molecular Chemistry and Catalysis in 1993 and her habilitation in 2007 from the University Paul Sabatier-Toulouse. She has been a CNRS Researcher at the LCC- Toulouse since 1996 where she has been the head of the group "*Engineering of Metal Nanoparticles*" since 2008. Her research interests concern the synthesis of metal nanoparticles and composite nanomaterials by using molecular chemistry concepts for their application in catalysis and energy. She is the co-author of ≈180 peer reviewed papers (including 8 reviews, 11 book chapters, 6 patents) and co-editor of 2 books "Nanomaterials in Catalysis" & “Nanoparticles in Catalysis: Advances in Synthesis and Applications” (2013 & 2021, Wiley-VCH).