

The Nanocar Race I and II

Christian Joachim^{1,2}

¹CEMES-CNRS, Université de Toulouse, 29 rue Jeanne Marvig, 31055 Toulouse, France

²MANA-NIMS, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan

Abstract:

In 2013, we proposed the organization of a molecule-car race regrouping on the same surface different molecule-vehicles driven one by one, at the same time, by pilots using different scanning tunneling microscopes (STM) [1]. This was one consequence of a long period of research on single molecule mechanics started with the first observation of a single molecule in rotation [2] followed by the construction of a few molecule(s) machinery like the single molecule-wheelbarrow [3], the molecular rack and pinion [4], a single molecule-rotor [5] and the first observation that a single molecule alone has enough power to rotate one way a few atoms [6] or another molecule [7].

With about 100 atoms, a molecule-vehicle has a molecular chassis equipped with spacer chemical groups to hold it a few angstrom away from the surface, paddles, switchable legs or wheels and a motorization embedded on board [1]. For this first edition, pushing its molecule-vehicle using the known pushing, pulling or sliding STM manipulation modes of a molecule was forbidden. It forced each team to play with inelastic tunneling effects for a drive on the Au(111) surface [8]. The 27th of April 2017 at 11:00 am, the departure flag was up in the Toulouse control room with the 6 selected teams from around the world on their starting atomic line, ready to nano-race. The anticipated run was 100 nm on a single Au(111) surface with 2 turns. After 2 days and one night of intense efforts, the 29th of April 2017 at 17:00 pm, the first ever international nano-car race was a success. We will describe the UHV technologies created on purpose for this race involving in particular a unique LT-UHV 4-STM i.e. a scanning tunneling microscope with 4 scanners able to scan on the same surface and a special UHV sublimation system with a dedicated masking set-up. We will present some of the nano-car race sequences recorded during those 36 hours.

In 2018, we have announced the nano-car race second edition for spring 2021 organized under the new MEMO (Mechanics with molecule(s)) FET European project. Ten teams from all over the world are already officially registered [9]. The rules of this second edition will be given in a way to attract more teams to join the fun of designing, synthesizing and operating a single molecule machinery on a surface.

References

- [1]: C. Joachim, G. Rapenne, *ACS Nano*, **7**, 11-14 (2013).
- [2]: J.K. Gimzewski, C. Joachim, R.R. Schlittler, V. Langlais, H. Tang, J. Johanson *Science*, **281**, 531 (1998).
- [3]: C. Joachim, H. Tang, F. Moresco, G. Rapenne, G. Meyer, *Nanotechnology*, **13**, 330 (2002).
- [4]: F. Chiaravalloti, L. Gross, K.H. Rieder, S. Stojkovic, A. Gourdon, C. Joachim, F. Moresco, *Nature Mat.*, **6**, 30 (2007).
- [5]: U.G.E. Perera, F. Ample, H. Kersell, Y. Zhang, G. Vives, J. Echeverria, M. Grisolia, G. Rapenne, C. Joachim, S.-W. Hla, *Nature Nano*, **8**, 46 (2013).
- [6]: R. Ohmann, J. Meyer, A. Nickel, J. Echevaria, C. Joachim, F. Moresco, G. Cuniberti, *ACS Nano*, **9**, 8394 (2015).
- [7]: P. Mishra, J.P. Hiel, W.V. Rossom, S. Yoshizawa, M. Grisolia, J. Echeveria, T. Ono, K. Ariga, T. Nakayama, C. Joachim, T. Uchihashi, *NanoLett.*, **15**, 4793 (2015).
- [8]: F. Eisenhut, C. Durand, F. Moresco, J.P. Launay, C. Joachim, *Eur. Phys. J. AP*, **76**, 10001 (2016).
- [9]: www.memo-project.eu/flatCMS/index.php/Nanocar-Race-II