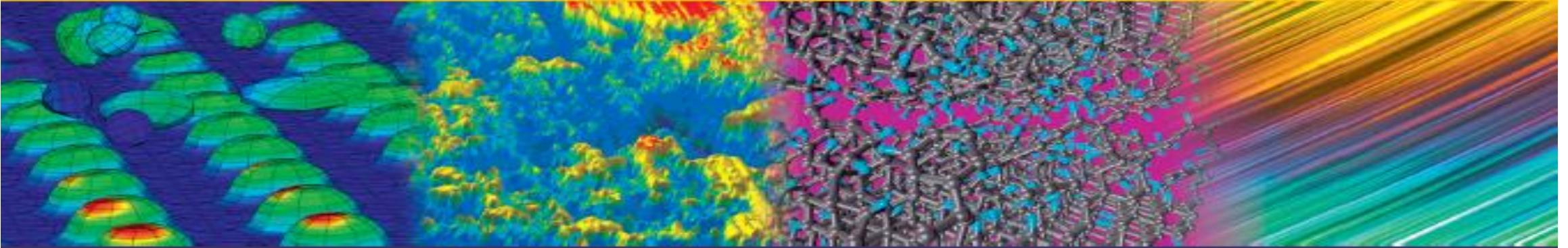


MIKROTRIBOLOGIE CENTRUM μ TC

EINE KOOPERATION VON FRAUNHOFER IWM UND KARLSRUHER INSTITUT FÜR TECHNOLOGIE KIT IAM



Driving Improvements in the Modern Automotive Powertrain with High Performance Lubricant Innovation

Mission

The MikroTribologie Center conducts tribosystem evaluation, tribosystem optimization and the development of multifunctional tribomaterials. Using the latest scientific findings as well as experimental, analytical and numerical tools, the μ TC develops new approaches to make



tribology calculable. The elucidation of friction and wear mechanisms on the micro- and nanoscale of materials and lubricants is the basis for industrially demanded research and development services.

Numbers

groups: 8

sites: Freiburg and Karlsruhe

employees: 100

tribometers: 40

profilometers: 10

annual turn over: 6 Mio.

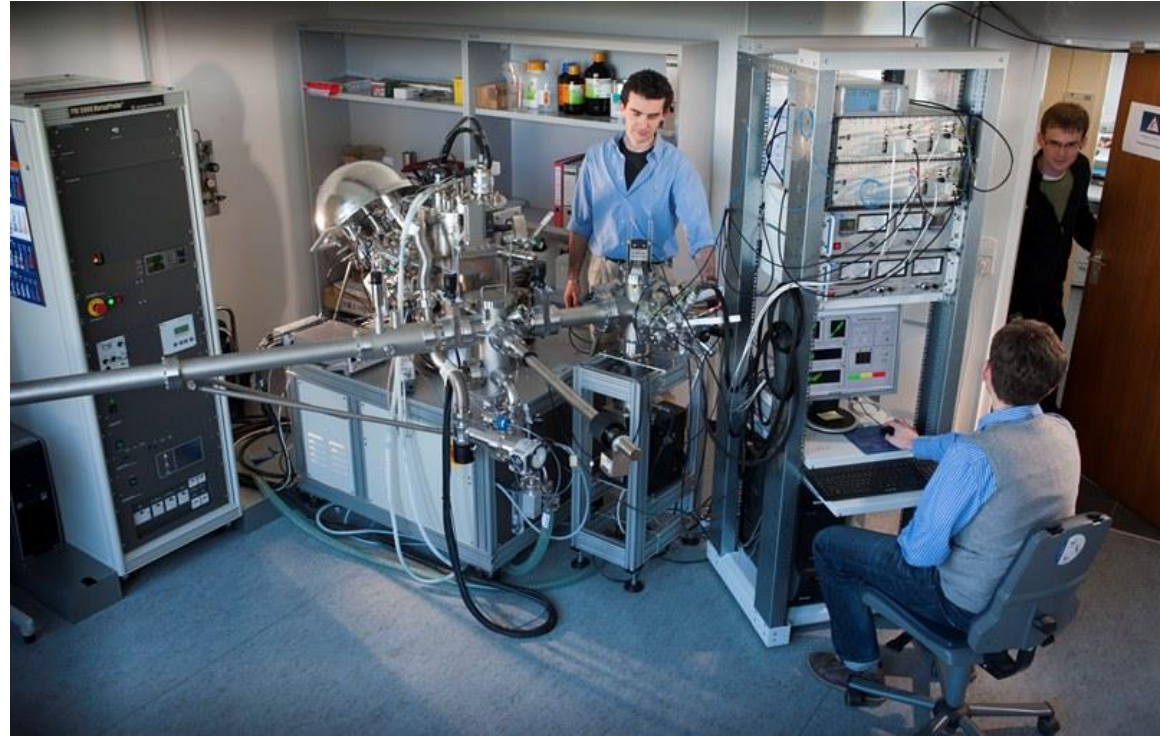
bearing testers: 5

gear box testers: 2

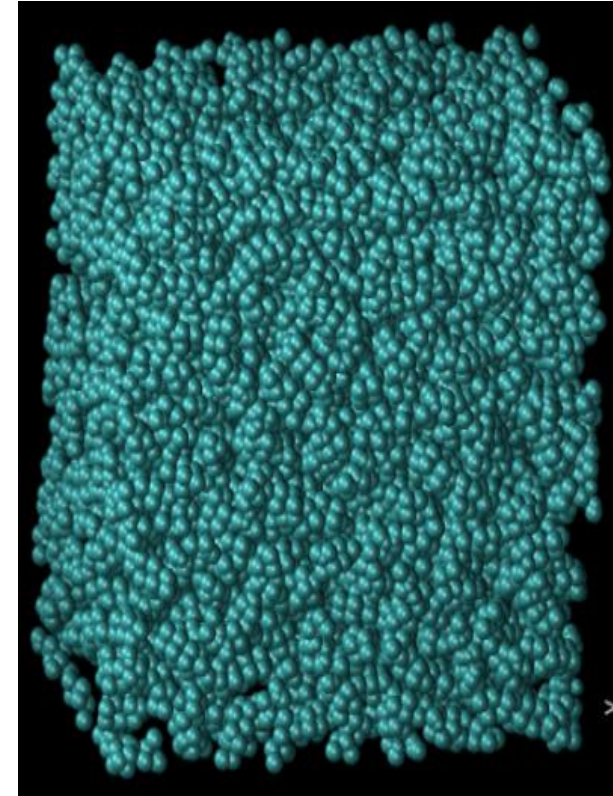
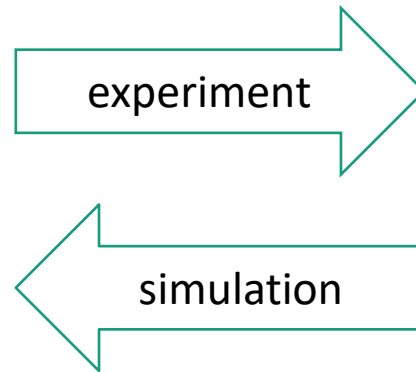
DLC/Diamond coaters: 10

investments between 2008 and 2017: 20 Mio. €

analytics: XPS, FTIR, ICP-OES, Raman, WLI, FIB, AFM



Lubricant Design by Combination of Surface Science and Atomistic Simulation



Synergetic and Antagonistic Interactions of Lubricant Components

Quartz Crystal Microbalance with Dissipation (QCM-D)

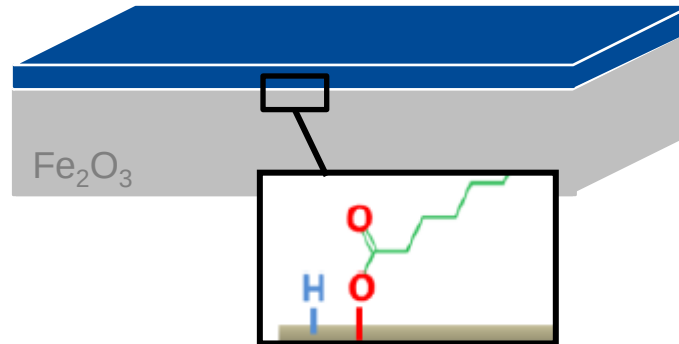
- amount adsorbed
- mechanical properties

Confocal Laser Scanning Microscopy (CLSM)

- film morphology
- film formation dynamics

in-situ Atomic Force Microscopy (AFM) - coupled with QCM

- combine quantitative and qualitative methods



Gas Phase Adsorption & XPS

- chemical bond analysis

Tribometer testing

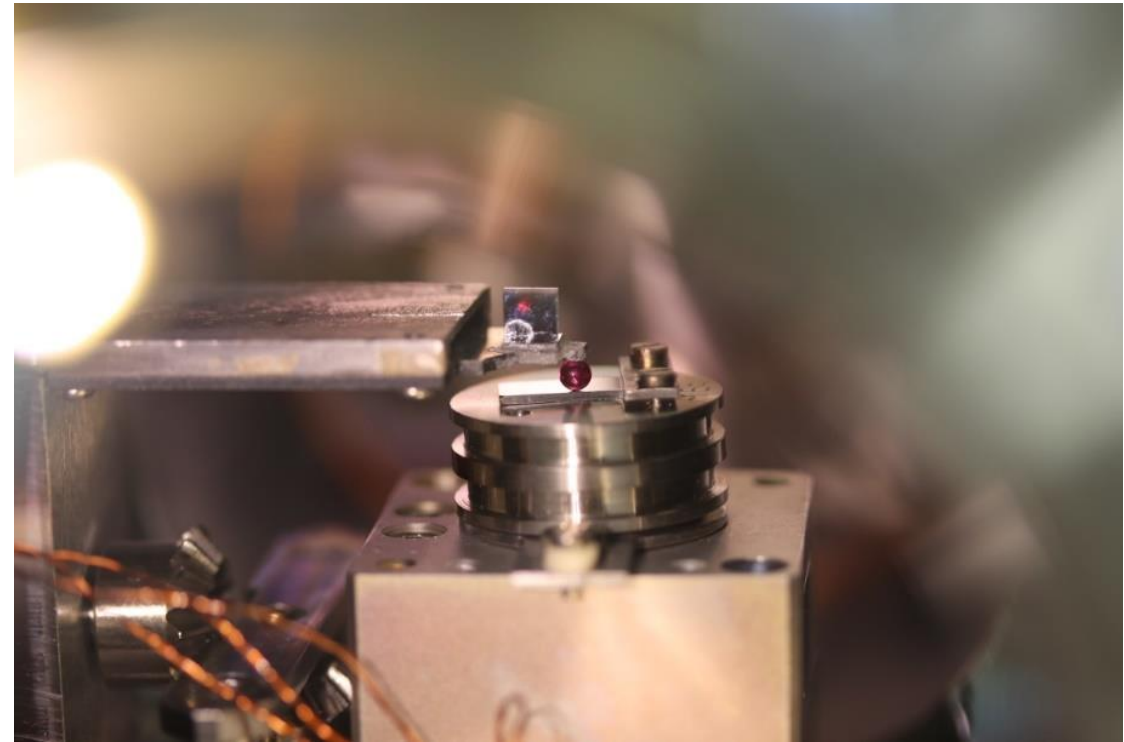
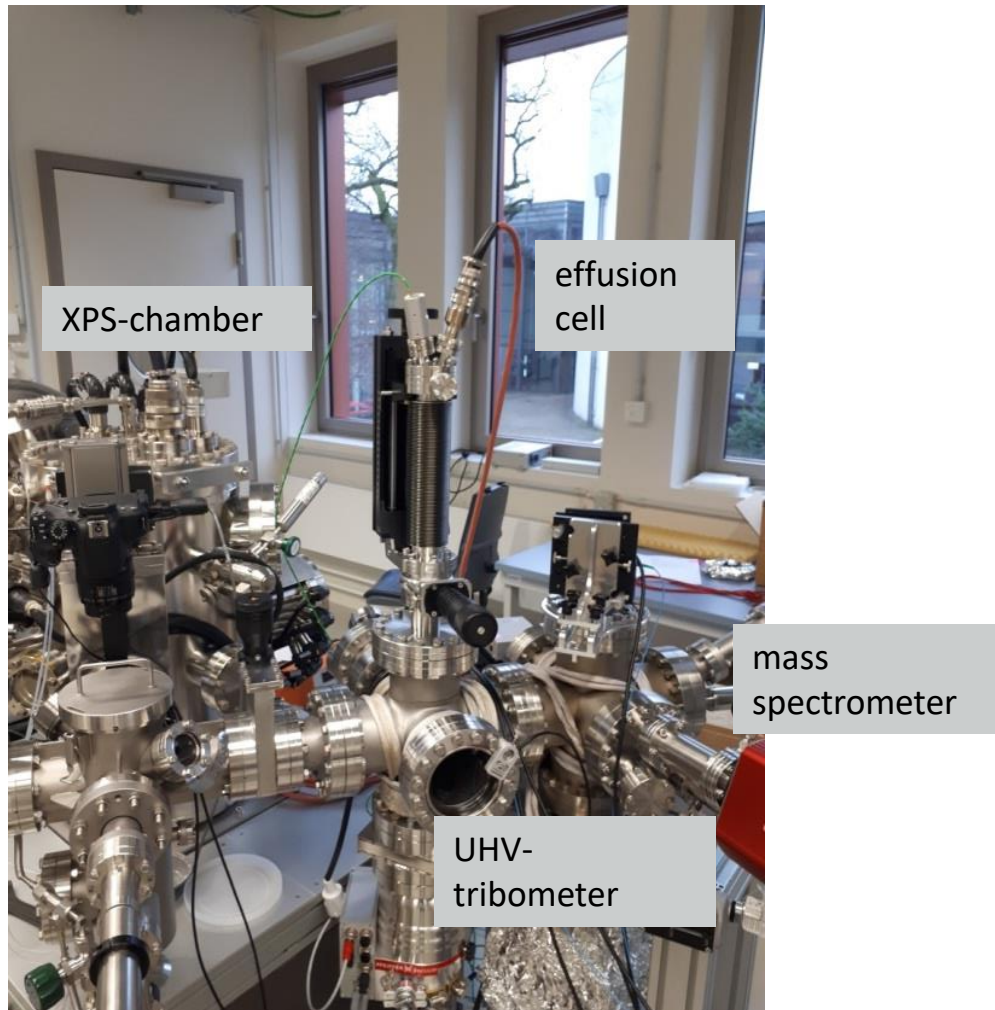
- ball-on-three plates tribometer
- RNT- SST

Corrosion tests

UHV- Tribometer & XPS

- influence of load and friction on chemical bonds

Vakuum Chamber with Effusion Cell, Tribometer and Mass Spectrometer



$$F_N = 5000 \mu\text{N} \text{ (130 MPa)}$$

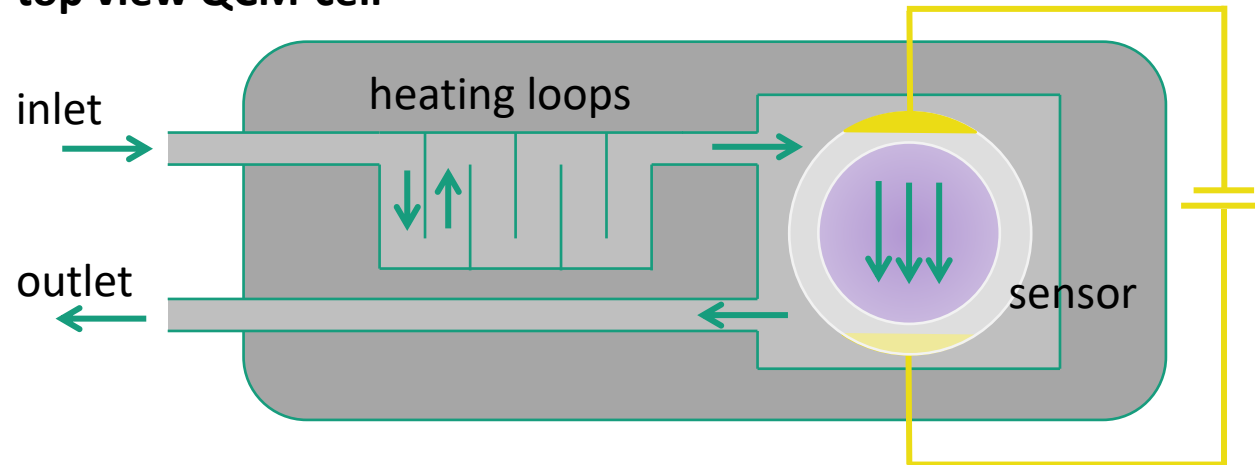
$$x = 100 \mu\text{m}$$

$$v = 50 \mu\text{m/s}$$

Quartz Crystal Microbalance with Dissipation (QCM-D)

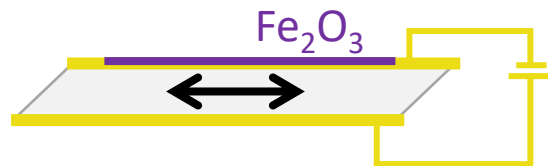
Studying Adsorption Processes – QCM-D set-up

top view QCM-cell



The QCM-D enables the measurement of adsorbed masses in the nanogram range as well as the determination of the viscoelastic properties of these layers.

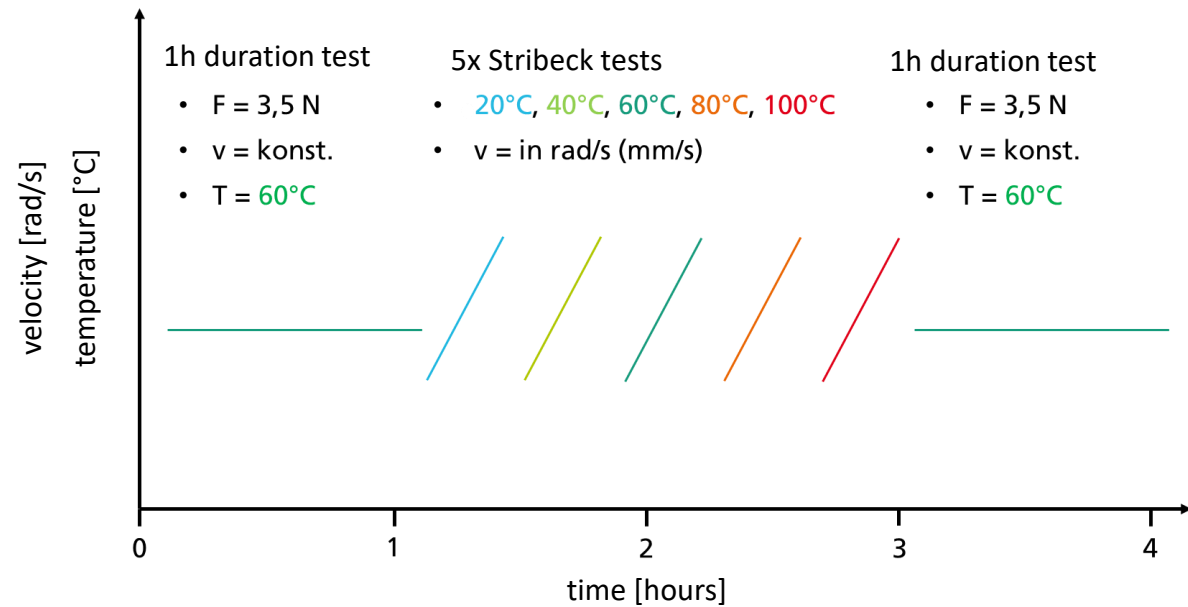
side view QCM-sensor



DHR3- Hybrid-Rheometer

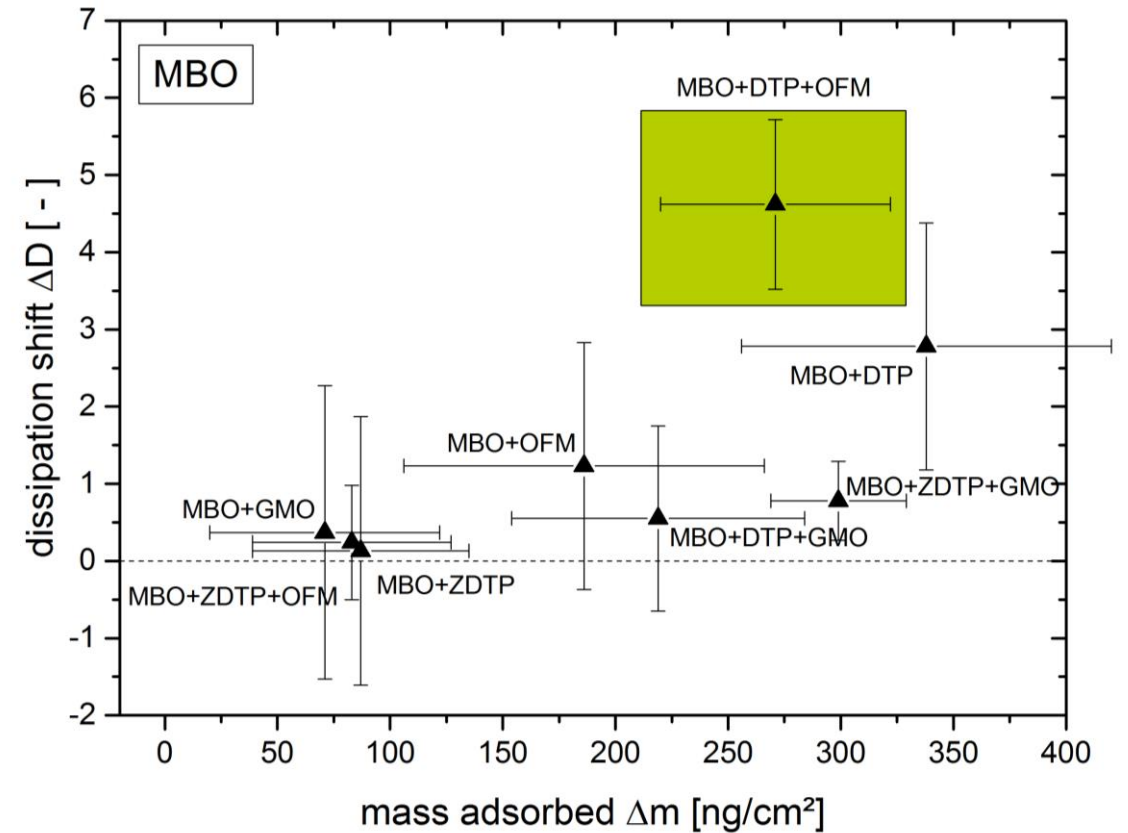
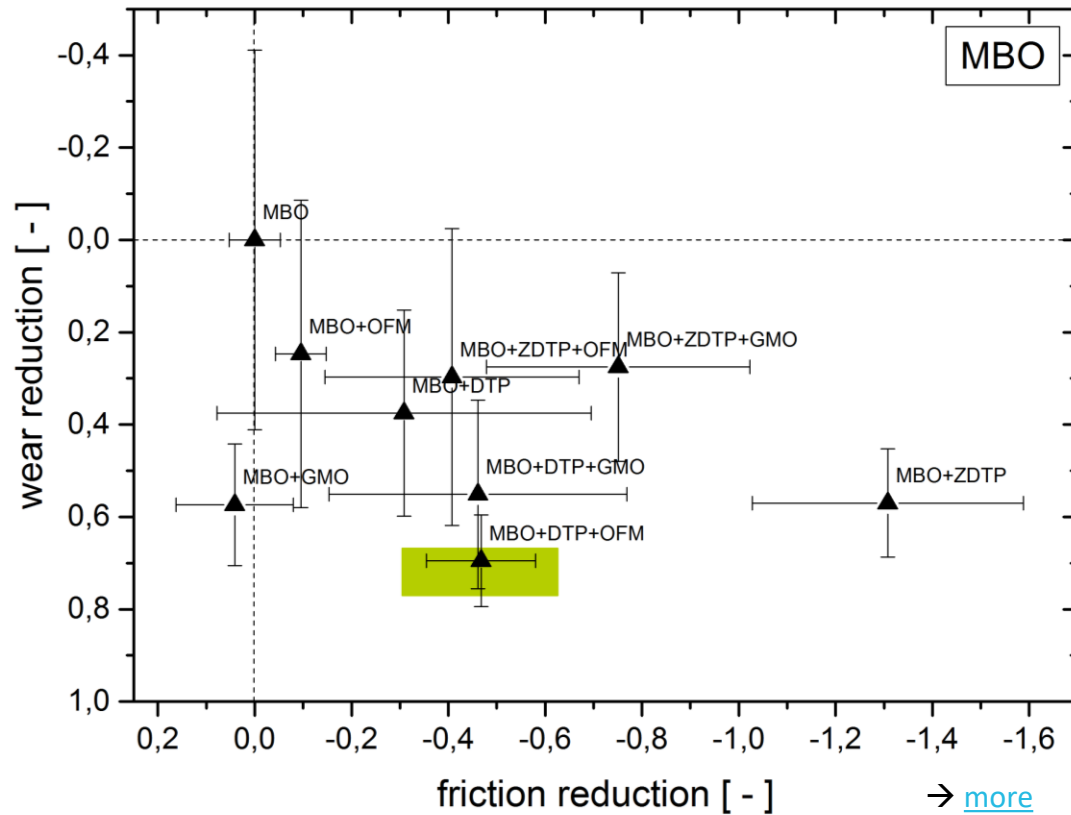
Ball-on-three-plates tribometer

315 MPa Initial Hertzian Pressure



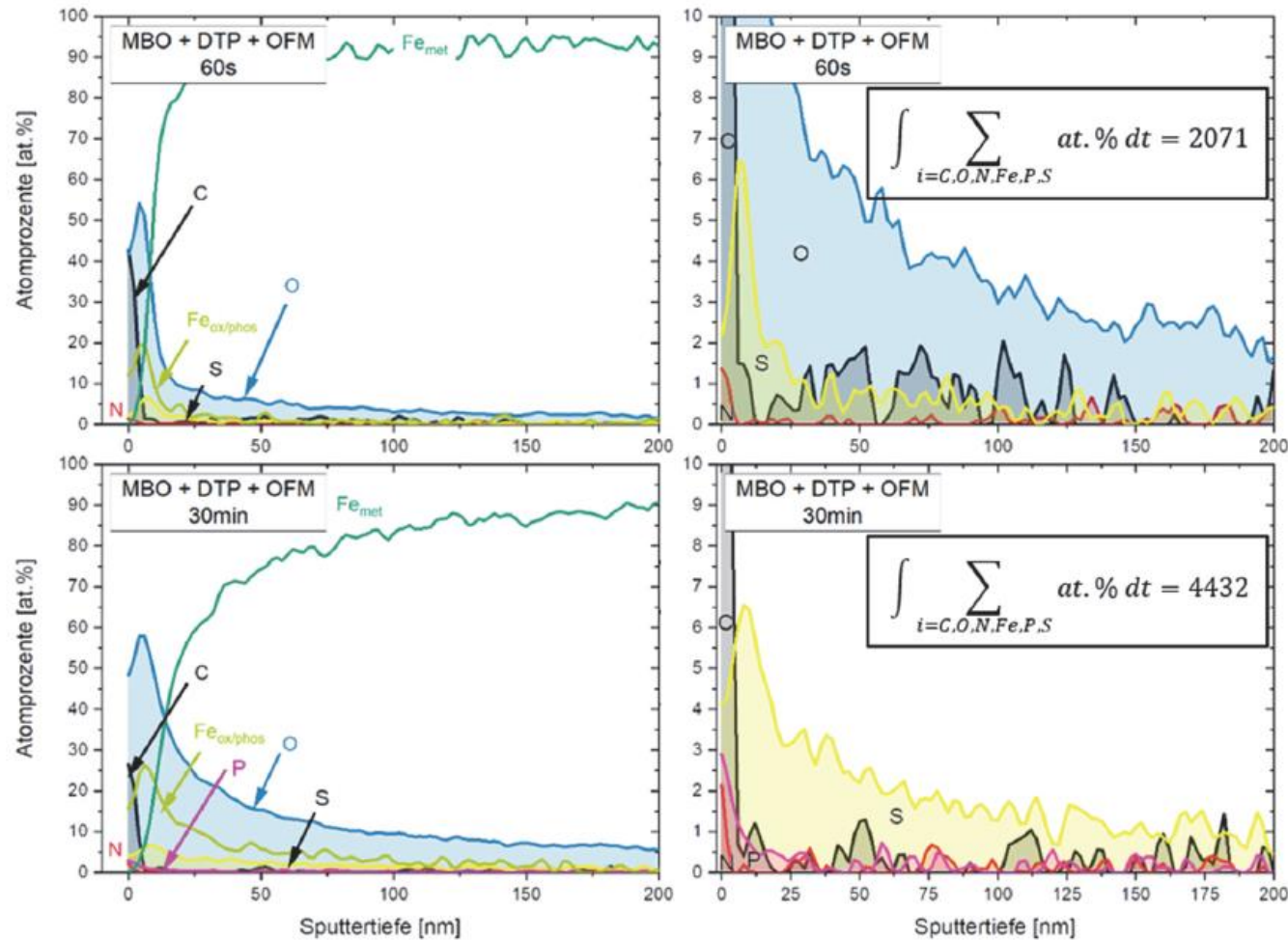
Synergy FM and AW – performance/QCM

MBO

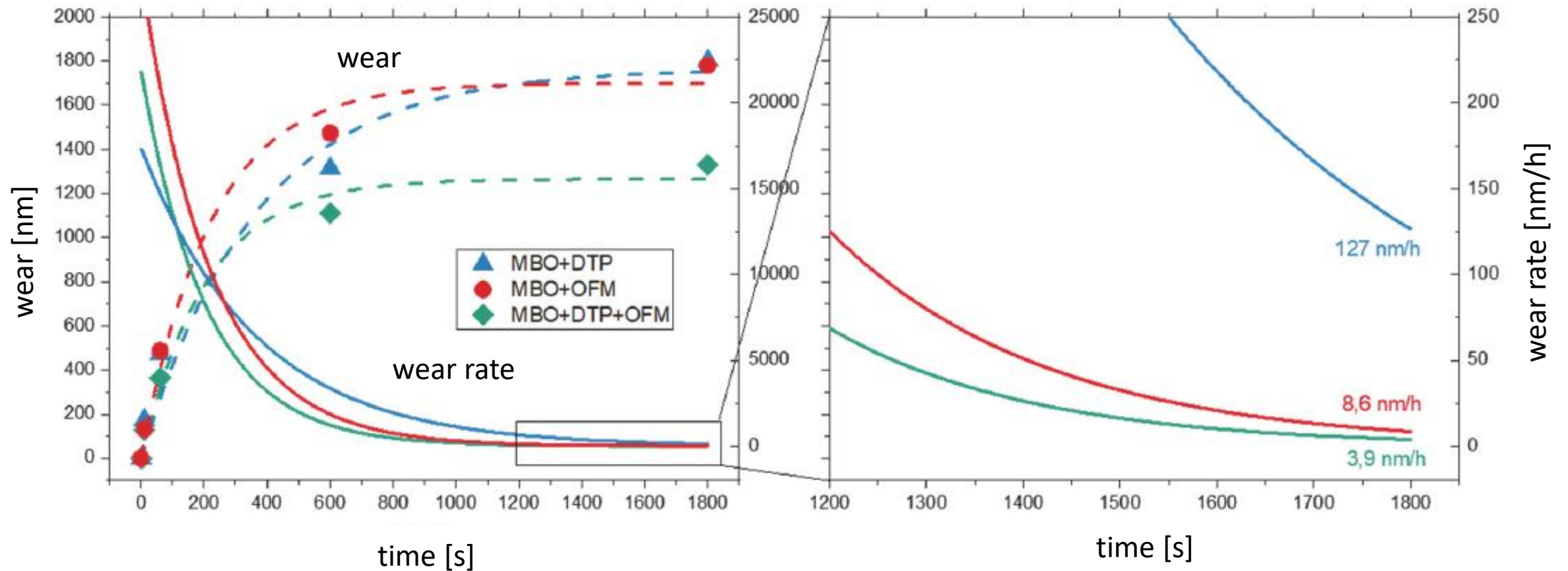


Synergy FM and AW - XPS results

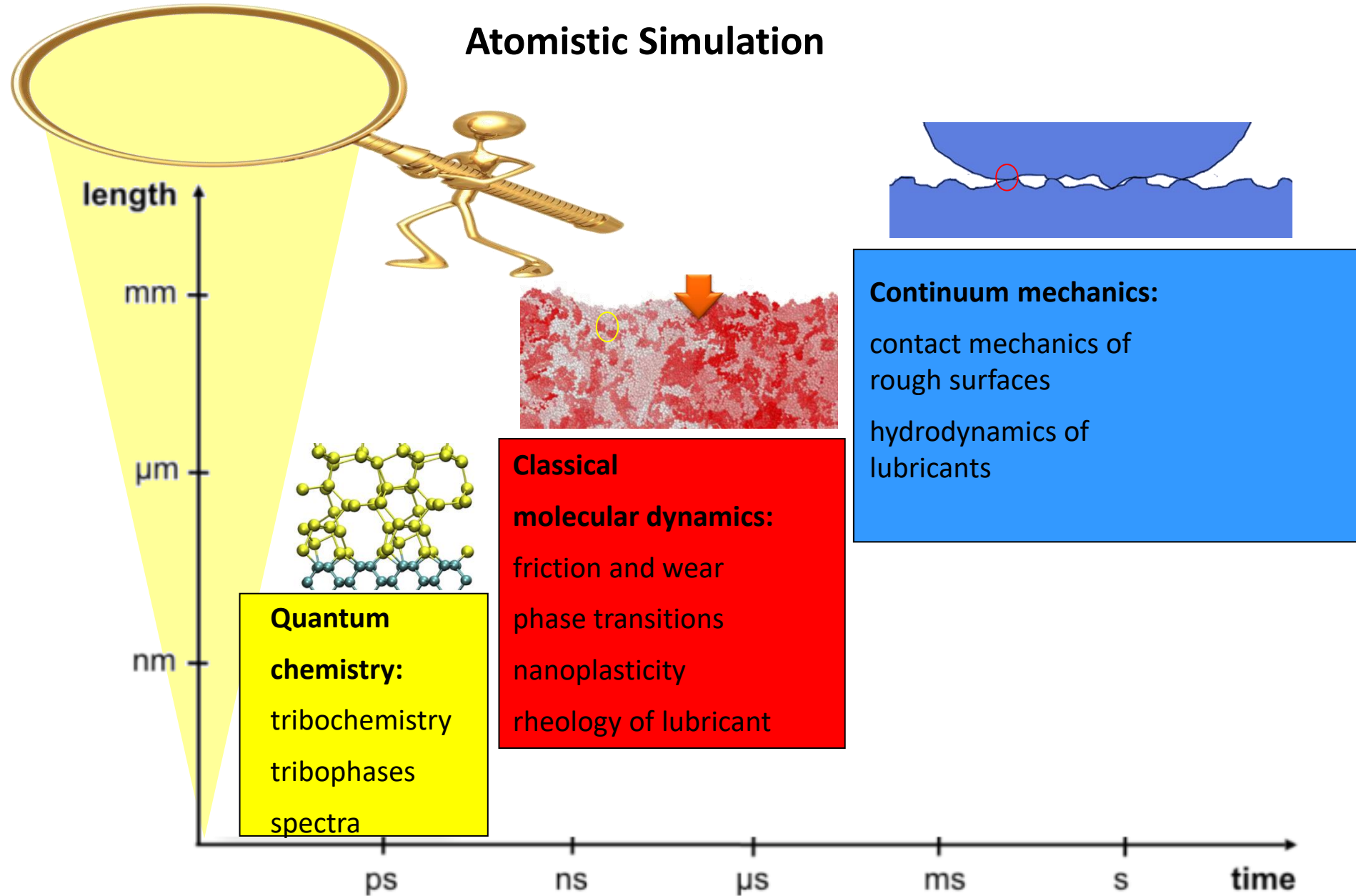
MBO + DTP + OFM



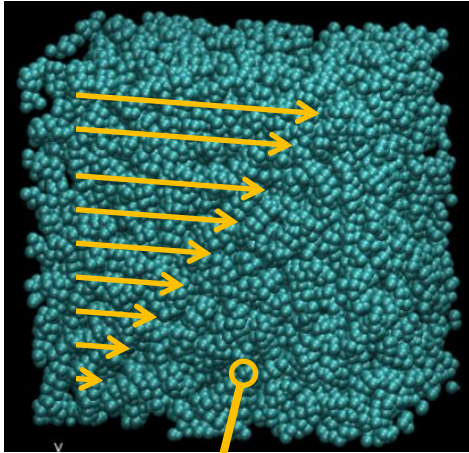
Wear Tests



Atomistic Simulation

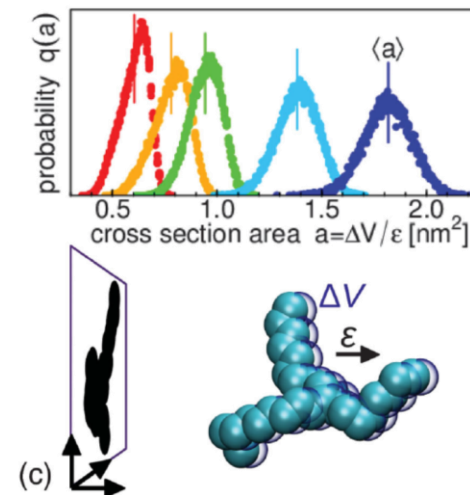
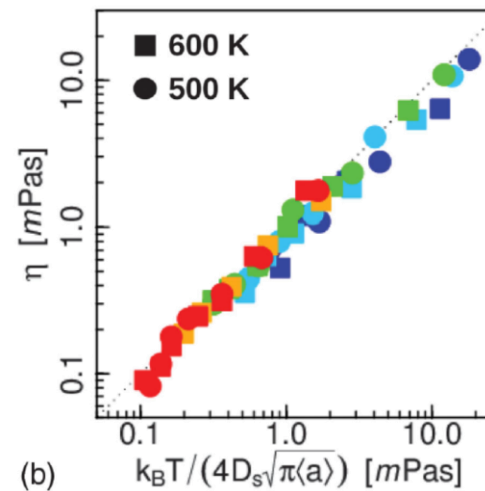
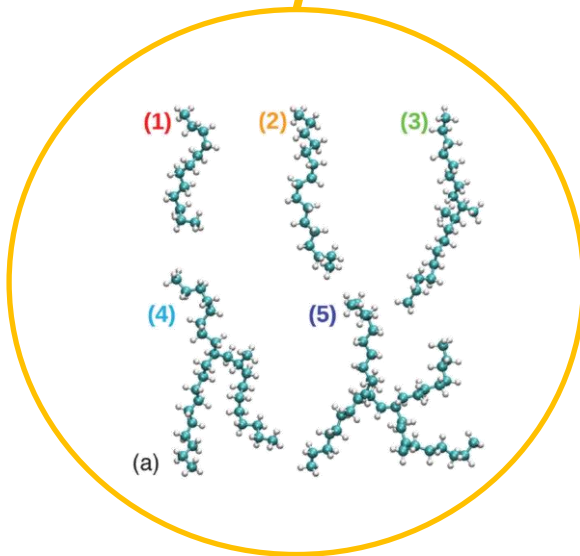


Prediction of Viscosities from Molecular Structure

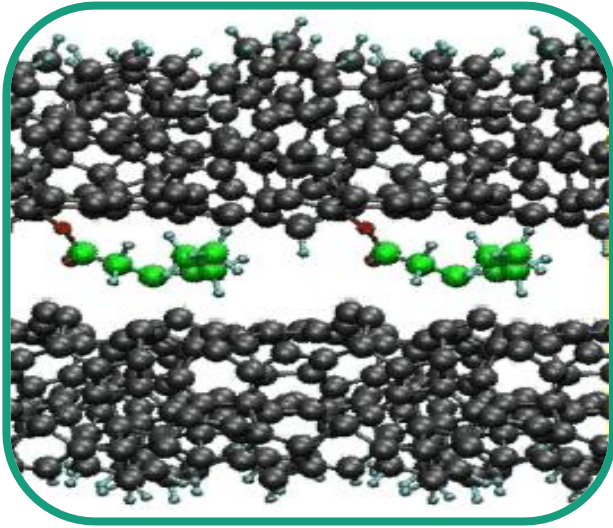


- **numerical calculation of viscosities** under extreme pressures and temperatures
- **formulation of physical models** by elucidation of atomic scale structure – property relationships

Example: hydrocarbon base oils – non-empirical Stokes-Einstein-Relation and Free-Volume-Theory allow for efficient modelling of viscosities.

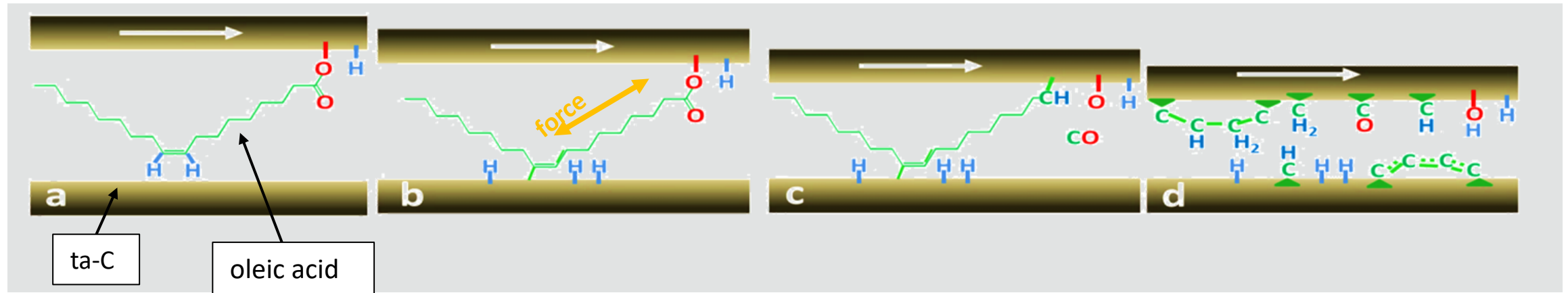


Mechano-Chemical Processes



Superlubricity for the ta-C / fatty acid / ta-C system

- motivation: experimental coefficients of friction < 0.01
- derivation of physical model for superlubricated surfaces by
- application of quantum-molecular dynamics for tribochemistry



Summary

- oil and additive design by combining real-time tribology and surface science
 - methods: QCM, XPS, microtribometry, rheometry
- using the synergy of experiment and atomistic simulation
 - methods: MD, DFT, FVT