Title: Development of adsorbents for preconcentration of VOC for their catalytic oxidation and detection
Place: Laboratoire Interdisciplinaire Carnot de Bourgogne, Dijon
Financial support: DECOLAIR project supported by the graduate school EIPHI, by the "Région Bourgogne Franche-Comté" and by FEDER (gross salary - 2 200 €).

Context: The presence of volatile organic compounds (VOCs) in the indoor air of habitats or industrial premises is a major risk factor for health. Currently, the most widely used purification method is the capture of VOCs on filters based on activated carbon. The major shortcoming of this technique is the saturation of the adsorbent, which depends on the concentration of VOCs, and the amount of air treated. Since it is difficult to predict the operating time of a filter, the adsorbents are provided for a fixed operating time. Once saturated, the adsorbents are generally burned with the VOCs they contain and replaced by new materials. There is no planned regeneration phase, as this would involve a complex operation to recover and manage desorbed VOCs on site.
An alternative approach to adsorption is the complete catalytic oxidation of VOCs. This technique transforms VOCs into H_2O and CO_2 continuously without any saturation of the adsorbent and therefore without the need for periodic maintenance. Despite the advantage of the catalytic route, it is not directly applicable to the purification of indoor air, since it is not suitable for the treatment of VOCs in low concentrations (< 1 ppm). To overcome this problem, VOCs must be preconcentrated before treatment. This could be achieved by first capturing the VOCs on an adsorbent material (preconcentrator) which will then be heated to desorb the captured species in more concentrated form. While being similar to a conventional filter, a preconcentrator must satisfy more strict criteria of use. Indeed, it must be able not only to adsorb VOCs in low concentration (like a filter), but also to restore them quickly during desorption at a moderate temperature (200 - 300 ° C). However, currently very little information is available on the role played by the composition and the structure of a porous solid in the key desorption stage. The same observation also applies to the optimal operating conditions for desorption. This lack of data makes it difficult to develop the effective method for purifying ambient air using the combination of preconcentration and oxidation catalysis.
Another important use of the preconcentration process is the analysis of VOCs in ambient air, which is crucial for determining its quality. As in the case of catalysis, preconcentration will increase the concentration of VOCs in the mixture analyzed and will therefore make their analysis more sensitive regardless of the method. The porous materials developed during this work will therefore find a double application in the context of ambient air purification. They will allow a more precise analysis of VOCs as well as their more efficient purification by catalytic oxidation.
Goals: This interdisciplinary thesis aims to study in depth the reactivity of porous solids of different nature as VOC preconcentrators for their catalytic oxidation and their detection. This study will define the properties of solids and the optimal operating parameters for effective preconcentration of VOCs. The most promising materials will be tested in catalytic oxidation and in detection devices.

Plan of the thesis:

- Synthesis and characterization of porous hydrophobic materials of different nature (zeolites and MOF (Metal Organic Framework)).
- Study of the properties of materials in the adsorption of target VOCs at low pressure in the concentration range representative of ambient air.
- Measurement and analysis of breakthrough curves for pure VOCs and in the presence of water vapor.

- Characterization of the influence of the porous structure and the operating conditions on the desorption profile of the trapped compounds.
- Preparation of VOC oxidation catalysts based on supported noble metals (in collaboration with J-F Lamonier, UCCS Lille).
- Adsorption / catalytic oxidation coupling tests for the most efficient porous materials.
- Use of porous materials developed in the preconcentration of VOCs for their detection (in collaboration with J-B Sanchez, FEMTO-ST, Besançon).

Candidate profile: Master's degree and/or Engineer in physical chemistry or chemistry of materials. Knowledge in adsorption, catalysis or characterization of solids would be appreciated. Strong taste for laboratory experimentation, curiosity and scientific rigor, autonomy and sense of initiative. Good writing skills (French and English).

Contact : Igor Bezverkhyy, CNRS researcher
igor.bezverkhyy@u-bourgogne.fr
Tél. : 03 80 39 60 38
ICB-UMR CNRS 6303, 9 av. Alain Savary, BP 47870, 21078, Dijon Cedex