Sujet de thèse 2024: Bourse Ecole Doctorale, Université Claude Bernard Lyon1

Microwave-Regenerable Sorbents-Catalysts.

Adsorbant-Catalyseurs régénérables par traitement micro-onde.

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Context.

Indoor air pollutions by Volatile Organic Compounds (VOCs) represent serious threats to human health. The origins of VOCs are diverse, e.g., furniture, floors, paints, humans or animals, heating and cooking systems, leading to complex mixtures of compounds. Formaldehyde, benzene, CO, acrolein, acetaldehyde and chloroform are among priority pollutants to be removed from homes, offices and schools. The two main control techniques are based on VOCs destruction and adsorption [1,2].

Destruction techniques (e.g. total oxidation through catalysis[3], plasma, ozonation, photocatalysis) are typically energy-intensive, costly and may result in the formation of secondary pollutants [1]. Adsorption can be effective but is limited by the need to replace or regenerate the sorbent[4]. A recent review [2] stressed the work still needed in improving VOCs control systems, in particular, (i) a fundamental understanding of the interaction between sorbents/catalysts and VOCs, (ii) the effect of water on sorption and (iii) combining Sorbent-Catalyst systems using bifunctional materials.

I.2. Objectives of the project

This project addresses several scientific shortcomings discussed above and propose innovative approaches to offer new cost-effective solutions in the destruction of VOCs, that may possibly lead to commercial applications.

First, *operando* IR spectroscopy will be combined with traditional sorption/volumetric methods to describe the adsorption of various VOCs in a set of representative sorbents to determine the main individual physicochemical adsorption parameters (sorption heat, isotherms, sites, coordination mode) and adsorption competitions by studying VOCs mixtures and water.

Second, sorbent regeneration will be done by using microwave heating similar to that of a standard kitchen appliance (2.45 GHz), as to develop a practical and inexpensive regeneration method [5,6]. The sorbent will be mechanically mixed with a catalyst composed of a support strongly absorbing microwaves and a phase active for total oxidation (Figure 1 and 2). The irradiation of the mixture will result in a sharp and rapid temperature increase of the catalyst that will result in the fast desorption of the VOCs. Desorbed VOCs will then be combusted over the hot catalyst in close contact. We recently published a paper proving the concept [7] (also for CO_2 trapping/valorisation [8]) and a video is available showing catalyst light-off:

Figure 1: Video at https://mycore.core-cloud.net/index.php/s/dln60fJNn8AiSUg

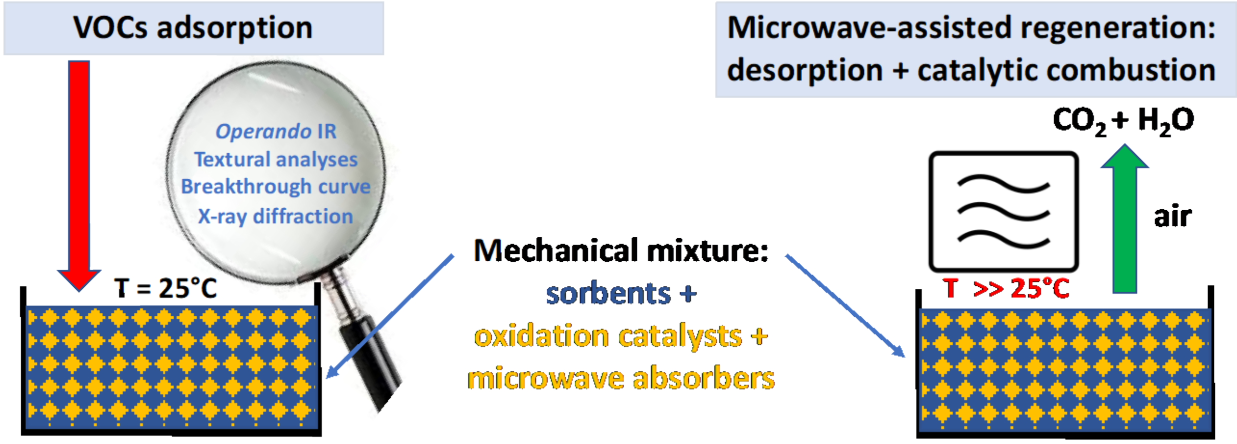

Figure 2. Schematic representation of the project: use various advanced characterization methods to understand VOCs adsorptions in sorbents and the ex situ regeneration in a common microwave oven. The system will consist of sorbents mixed with oxidation catalysts exhibiting high dielectric constants.

The efficiency and durability of the elimination of priority VOCs on a limited set of sorbents (zeolites, porous polymers, MOFs and activated carbons) mixed with various catalysts will be determined. A major focus will be to ensure that no harmful secondary products are produced during combustion/regeneration, or at least at acceptable levels based on legal exposition limits.

The supervising TEAM are team members of the ATARI group of IRCELYON (https://www.ircelyon.univ-lyon1.fr/en/team/integrated-thermodynamical-reactional-and-analytical-approaches/) having complementary knowledge on this topic. Dr Meunier's PhD students typically finish their thesis within 3 years with at least 4 papers in mainstream journals.

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