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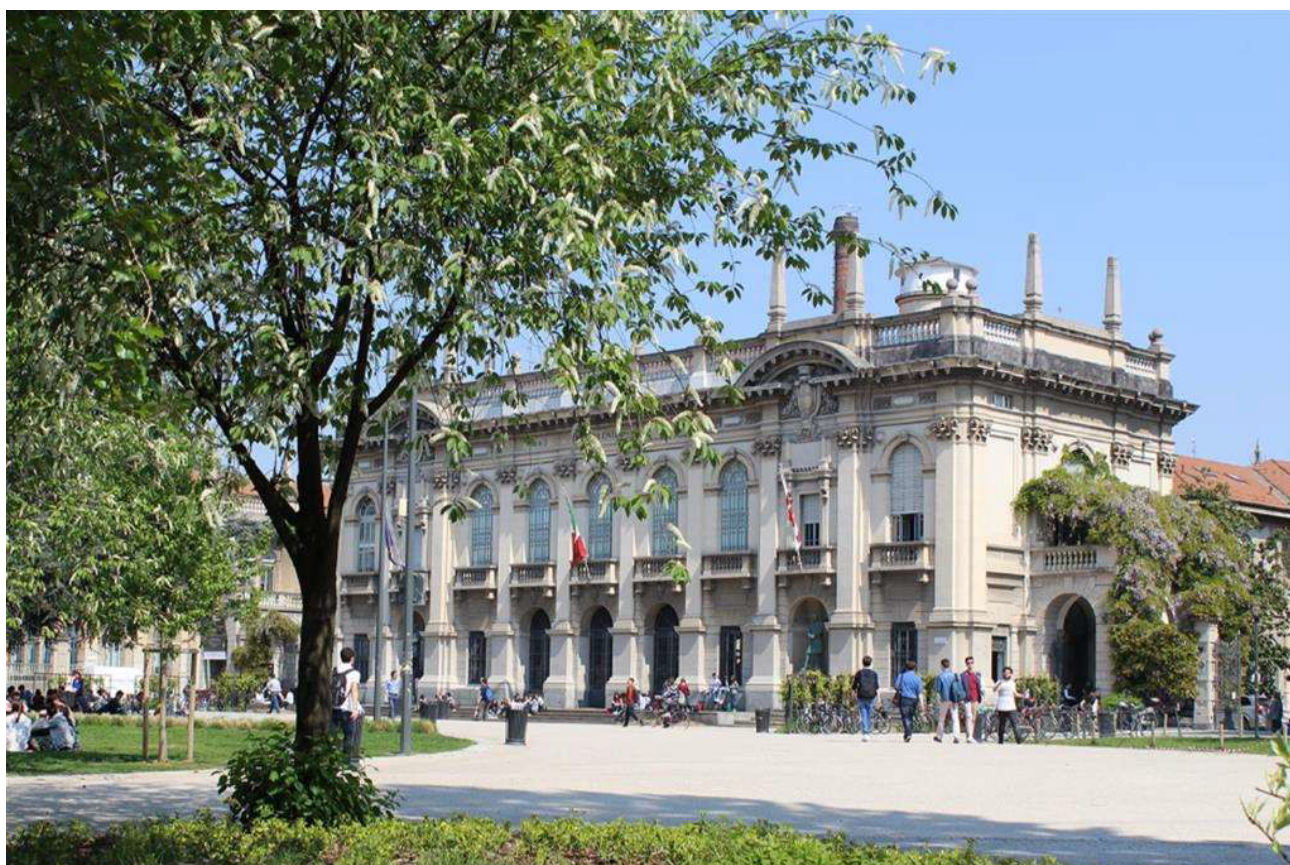


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Divisione di Chimica
per le Tecnologie

XIII Congresso Nazionale AICIng e II Congresso Nazionale della Divisione di Chimica per le Tecnologie della SCI



ATTI DEL CONVEGNO

25-28 giugno 2023
Politecnico di Milano

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per le Tecnologie della Società Chimica Italiana**

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°C, CM absorbs 0.44 kg/m³ of H₂ while the uptake of H₂ for CaMnO_{3±δ} is 0.98 kg/m³ (Figure 1).

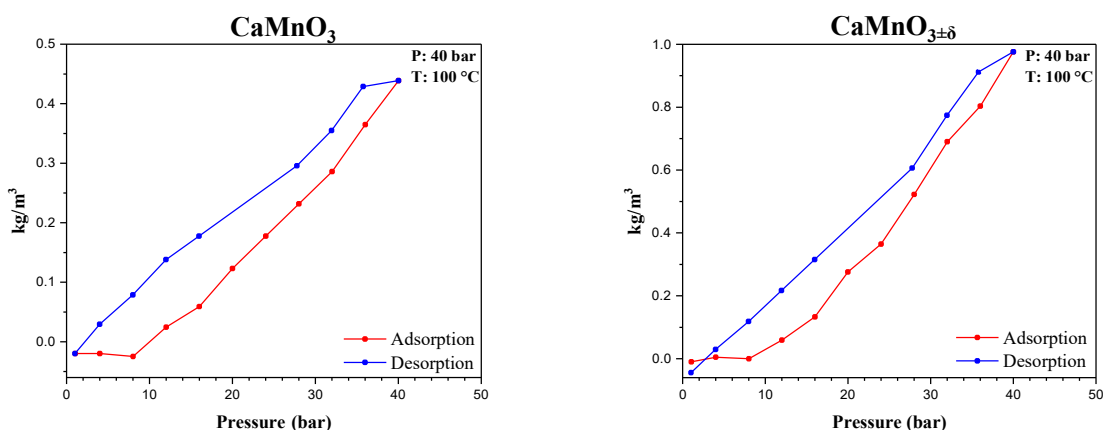


Figure 1. Adsorption/desorption of H₂ at 40 bar e 100 °C for CaMnO₃ and CaMnO_{3±δ}.

In order to enhance the storage capacity of these oxides, we are also investing the addition of 1% wt. Pd⁰, which should promote the dissociation of hydrogen and, therefore, improve the ad/desorption kinetics of this gas. As a result, we observed that, at the same experimental conditions, the materials in presence of Pd⁰ absorbs a significantly larger amount of H₂ 12.88 kg/m³ and 44.95 kg/m³ respectively (Figure 2). What is more, they are able to retain it for future utilization.

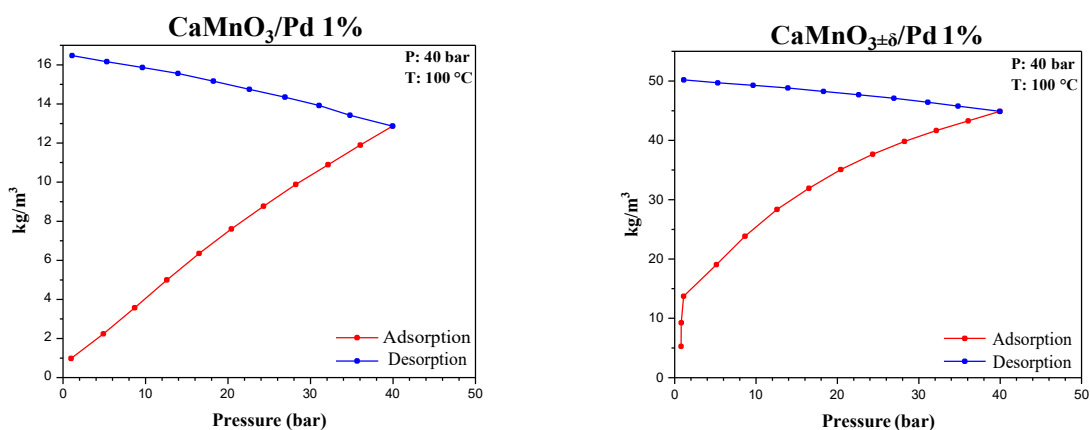


Figure 2. Adsorption/desorption of H₂ at 40 bar e 100 °C for CaMnO₃/Pd 1% and CaMnO_{3±δ}/Pd 1%.

Further studies are ongoing to investigate the gas release conditions and eventual structural modifications to better understand the mechanism by which hydrogen is stored and consequently improve the storage efficiency.

References

- [1] International Energy Agency (IEA). *Key World Energy Statistics*, 2020.
- [2] D. J. Durbin, C. Malardier-Jugroot, *International journal of hydrogen energy*, 2013, 38(34), 14595- 14617.
- [3] M. S. El-Eskandarany, *RSC advances*, 2019, 9(18), 9907-9930.
- [4], S. M. A. A. Ibrahim, *Korean J. Chem. Eng.*, 2014, 31, 1792-1797.

Towards the recovery of metals from spent lithium-ion batteries: an academy-industry joint venture to face the several challenges

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Lithium-Ion Batteries (LIBs) are electrochemical devices almost ubiquitous today, from portable electronics to electric vehicles. The presence of some critical materials (e.g., Co, Ni and, from 2020, Li) is forcing the scientific and industrial community to find out effective strategies to recover such materials from the constantly increasing spent LIBs. This is a critical target for the reduction of the EU's socio-economic dependence on foreign Countries for this strategic technology. Today, pyrometallurgical technologies for spent LIBs treatment are available, however the stringent recovery rate defined by EU for the coming years can only be achieved by developing efficient hydrometallurgical recovery processes.

Despite the relatively simple working principle, LIBs are very complex devices in which many different materials are tightly compressed, stacked or rolled together to craft objects with the plenty of combination of chemistry, shape and dimension available on market. This great variety entails challenges for the recycling processes. Firstly, an automatic opening/disassembling step of spent LIB cells aimed at removing the two electrodes (and the separator) intact from the protective case is a very hard task especially when thinking about industrial volumes. At the moment, the only industrially acceptable way for treating spent LIBs is to shatter them, originating heterogeneous mixtures of strips (or, in worst conditions, agglomerates) of metallic case, plastic separator and shielding, and current collectors on which the electroactive materials is attached (metal oxides on the cathode and graphite on the anode). After a step deputed to detach as much active material as possible, this black mass is sent to the chemical stages of a hydrometallurgical process aimed at dissolving the metal compounds.

Secondly, to overcome the difficulty in sorting the incoming spent LIBs by their chemistry, and considering the need to recycle all of them, the development of a robust