Optimization of a system for the upcycling of organic waste by sorption-enhanced methanol synthesis

Chiara Berretta [a], Andrea Mauro Pappagallo [a], Tilman Schildhauer [a], Oliver Kröcher[a], Emanuele Moioli[b]

[a] Paul Scherrer Institute, Villigen, Switzerland
[b] Politecnico di Milano, Milano, Italy

E-mail: emanuele.moioli@polimi.it

The valorisation of biogas is an important option for the circular economy, as it allows upcycling biogenic carbon in useful product. Among the possible synthesis routes, the production of methanol from biogas with and without addition of green H_2 appears as a convenient option. Unfortunately, the high concentration of CO_2 in biogas hinders the application of standard methanol synthesis methods, as the methanol formation from CO_2 is less favourable than from CO from a thermodynamic point of view.

To overcome the previously-mentioned limitation, we designed a novel system to take advantage of the sorption-enhanced methanol synthesis from CO_2 or biogas. Sorption enhancement allows increasing the both the yield to methanol and the reverse water gas shift reaction. The result is that the unconverted gases have a favourable CO/CO_2 ratio to be processed in a standard methanol reactor downstream. We performed first a sorbent screening, discovering that the optimal sorbent for the sorption-enhanced methanol synthesis is the zeolite 3A, which efficiently removes water from the product mixture, without affecting methanol. Based on the experimental results, we optimized the technical reactor in terms of dimensions, temperature and time on stream. We then performed a combined process-reactor optimization, highlighting the trade-offs between reactor and process performance, in particular in terms of productivity vs. requirement for recycle of the unreacted gases. The result is an optimized reactor to be inserted in a biogas to methanol system, enhancing the profitability of the system and favouring the implementation of circular economy routines.

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