

Evaluation report on the PhD dissertation:

“Study on polydimethylsiloxane membrane contactors to recover dissolved gases (CH₄, CO₂) from anaerobic effluents”

by: Merve Visnyei

The topic of the thesis, the recovery of dissolved gases, namely methane and carbon dioxide, with membrane technology, is a very forward-looking topic. The candidate examined this phenomenon in connection with a wastewater treatment step, but its importance goes beyond this, the information obtained here can be applied in other areas as well.

I am in such a fortunate position that I was able to read the thesis before the home defense as well. The candidate took into account many of my comments and suggestions, so this time I had much less work to do.

The Introduction, which was missing during by me the home defense, has been included in the thesis yet and really draws the reader's attention to the topic and the importance of the topic.

In the **Literature review**, the candidate immediately highlights a detail that may not have been specified in the title: anaerobic effluents actually and fundamentally mean wastewater.

The processing of the topic is extensive it has some specific literary examples. More critical analysis would have further increased recognition. A lot of relevant literature was processed/referenced in the thesis, but some statements would need to be confirmed by some one. (i.e.: p. 20: “As a result, the gas/liquid membrane contactor (GLMC) process has a lower energy consumption than traditional separation methods.” p. 21 : „When comparing the two operation modes, specifically feeding the liquid phase into the lumen or shell side of the membrane module, it has been observed by researchers that feeding the liquid into the lumen side yields better outcom”

The issue of the global problem of methane dissolved in wastewater is perhaps debatable, compared to other greenhouse gases, but for now we can safely ignore this debate. It is interesting, however, that fig.5, "Dissolved methane in the wastewater as a function of temperature" clearly shows the strong temperature dependence, but raises the question of what kind of wastewater this is, what its origin is, what COD and BOD it is characterized by. Since this figure will be referred to several times later on, it would be important to clarify these basics. Is the solubility of a digester effluent the same?

The **Goals** of the research work exactly cover what is described later in the Results and Discussion chapter.

The **Method** chapter also presents the details according to the threefold division of the experimental work.

Otherwise, the chapter describes the methods, calculation methods, equipment and their characteristics belonging to all three subchapters very carefully and in detail. Only a few open questions or unclear information remains. e.g.:

- Why exactly these gas mixture ratios were used?
- What microbial community did you use for the anaerobic process?

Results: Series#1

During Series#1, the membrane module and pilot system were tested with gas recovery measurements for clean gas or in the case of a methane/carbon dioxide gas mixture.

The CO₂ recovery data can be easily interpreted with the Prandtl film theory. The methane recovery data can really be explained well by the determining role of the resistance on the liquid side, which is almost the same in all cases, due to the same flow rate. The measurement data reported in the paper are not in line with Cookney's statement: "This observation aligns with findings reported by Cookney et al. [89], who noted minimal impact on the mass transfer coefficient of CH₄ with increasing gas flow rates, attributed to mass transfer being controlled by resistance in the liquid phase." because in Tables 9 -10 the liquid-side resistance does not change, only the gas-side resistance is changed, which is also reflected in the recovery efficiency...a monotonic increase in the case of CO₂, but not in the case of CH₄

But how can the considerable decrease are explained at a sweep gas flow rate of 60 ml/min?

Series#2

At first, it would be advisable to clarify the concepts of "model solution" and "synthetic effluents" and "synthetic anaerobic effluents", because they are also used as synonyms for each other in the thesis, even though the names cover different things and this is very confusing.

The thoroughness of the candidate and the research group is proven by the fact that the proof of the stability of gas mixtures is also presented. The obtained results: "a higher liquid flow rate can increase the desorption of gases", unsurprisingly, agree nicely with the expectations and the results of other researchers.

It is said on the page 61: „An increase in the liquid flow rate led to a decrease in CH₄ recovery for all synthetic effluents.” it is correct and proved by Fig. 22. But the explanation is no longer so easy to see, because the explanation taken from the cited literature (M. Henares, M. Izquierdo, P. Marzal, and V. Martínez-Soria in Sep. Purif.Technol.) attributes the "deformation and compression of fibers" to the effect of pressure, the effect of the pressure difference, not to the flow rate.

„The reason for the lower pressure limit from shell to lumen is because the hollow fibres may collapse and be damaged if the pressure from the outside of the hollow fibre to the lumen side of the hollow fibre exceeds 1050 mbar. On the other hand, if the pressure from the lumen side

to the outside of the hollow fibre exceeds 3100 mbar, the hollow fibres may over-distend and potentially be damaged.”

Series#3

Without a doubt, Series#3 is the most exciting, meaningful and valuable chapter in the thesis. The chapter very well points out the difficulties we have to face when working with real environments. Such was, for example, the issue of optimal glycerine dosage, which the Candidate solved very well. The other significant challenge was the membrane clogging, since the 1 mm pre-filtration still allows a lot of resistance/deposition-causing materials to pass through.

The figures are basically well designed and easy to interpret but unfortunately a few figures show a standard deviation only.

Thesis Statements

The I., II. III. and IV. statements are accepted as new scientific results, with the fact that III. point content is more technical/engineering than scientific, but this is considered relevant because of the doctoral school (Doctoral School of Chemical Engineering and Materials Science).

Overall, the Candidate has published an extremely substantial and valuable work, which meets the requirements for dissertations in both its scientific content and form.

Therefore, I would like to state that, if the dissertation is successfully defended, I recommend its acceptance and the award of the doctoral degree to the Candidate.

Questions:

How do you think the process of membrane transport is affected by whether it flows on the lumen side or the shell side?

How are the amounts/ratios of the two gases formed in a real fermentation effluent?

Figure 5 shows the temperature dependence of the amount of dissolved oxygen in water. How do these values change in real wastewater?

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Cecilia Hodúr