

The Extraction and Recovery of Volatile Fatty Acids with a Complex Coacervate

T. Brouwer¹, R.C. Oosterhoff¹, T.R. Engelen¹, B. Schuur¹, S. Lindhoud²

¹Sustainable Process Technology Group, University of Twente, Enschede, The Netherlands

²Nanobiophysics, University of Twente, Enschede, The Netherlands

Introduction:

- Rising concerns regarding the depletion of natural gas and oil reserves and the expanding will to transit to more sustainable economies.
- Alternative sources of chemicals are needed
- One of the suggested solutions is obtaining chemicals, e.g. volatile fatty acids or VFAs, via the fermentation of organic waste streams.
- Traditional separation techniques are not economically feasible. We attempt to provide an alternative solution using complex coacervates.

Complex Coacervate: A complex coacervate is an agglomeration between two polyelectrolytes. Upon mixing these polyelectrolytes, under the right circumstances, e.g. temperature, molar ratio, salt concentration, either a homogenous solution, a precipitation or a complex coacervate will be formed due to the entropic gain of releasing the counter ions. The liquid complex coacervate was used to extract VFAs from an aqueous solution.



Figure 1: A schematic representation of the formation of complex coacervate with polyacrylic acid and (branched) polyethyleneimine.

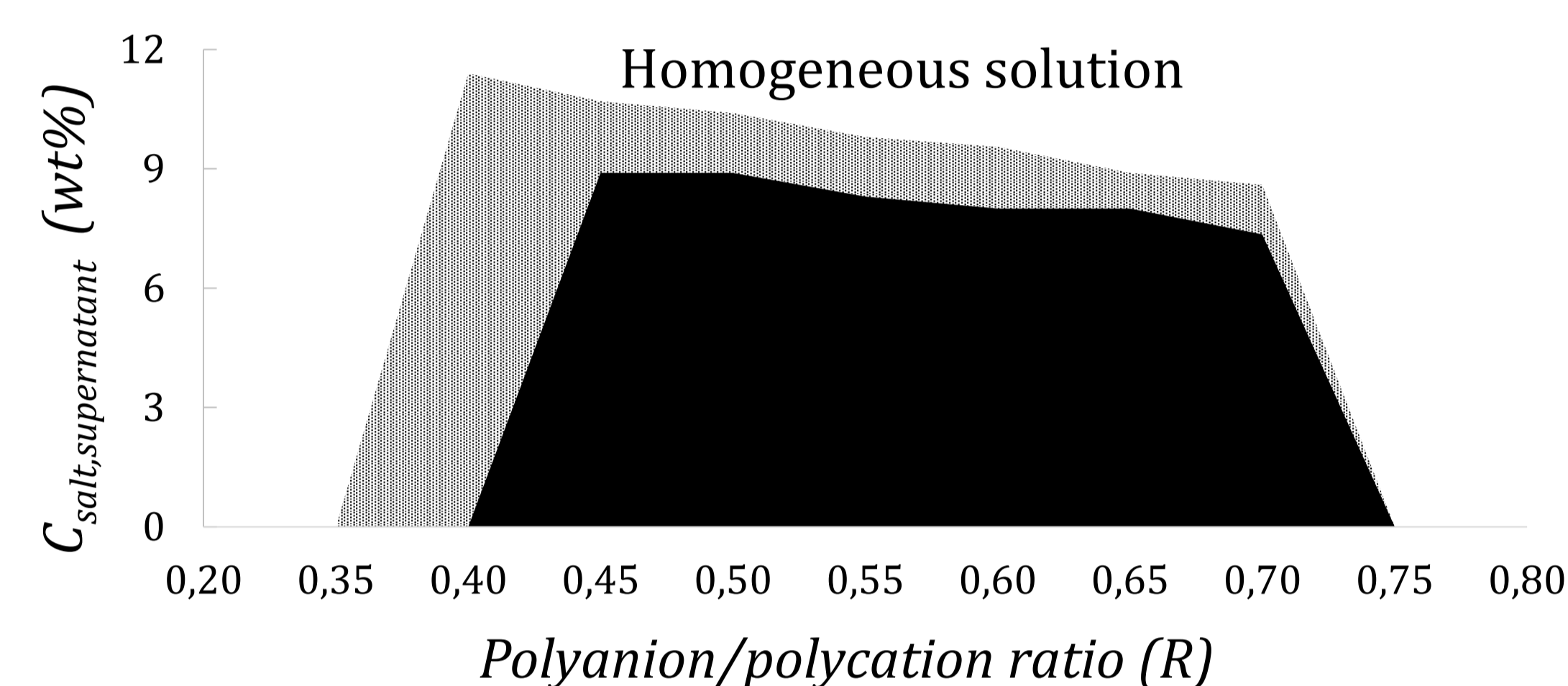


Figure 2: Solid-Liquid Equilibrium Diagram of the polyelectrolyte ratio and salt concentration

Extraction: Several cross-current extraction procedures were performed. The feed solution was a model system resembling a fermentation broth. The solution contains 1 wt.% acetic acid and 2.5 wt. % of salts (Na^+ , K^+ , Cl^- , HPO_4^{2-} , SO_4^{2-}).

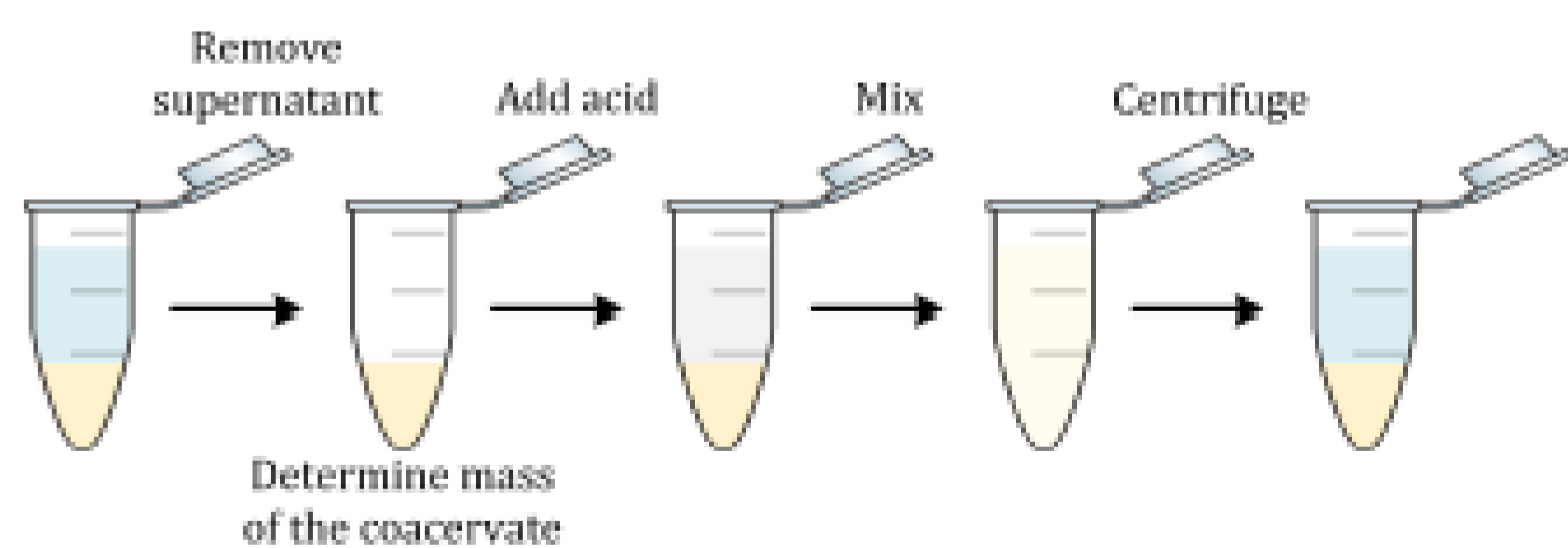


Figure 3: The cross-current extraction step.

A sequence of 8 cross-current extraction where performed following the procedure in Figure 3. This set of experiments resulted in Figure 4.

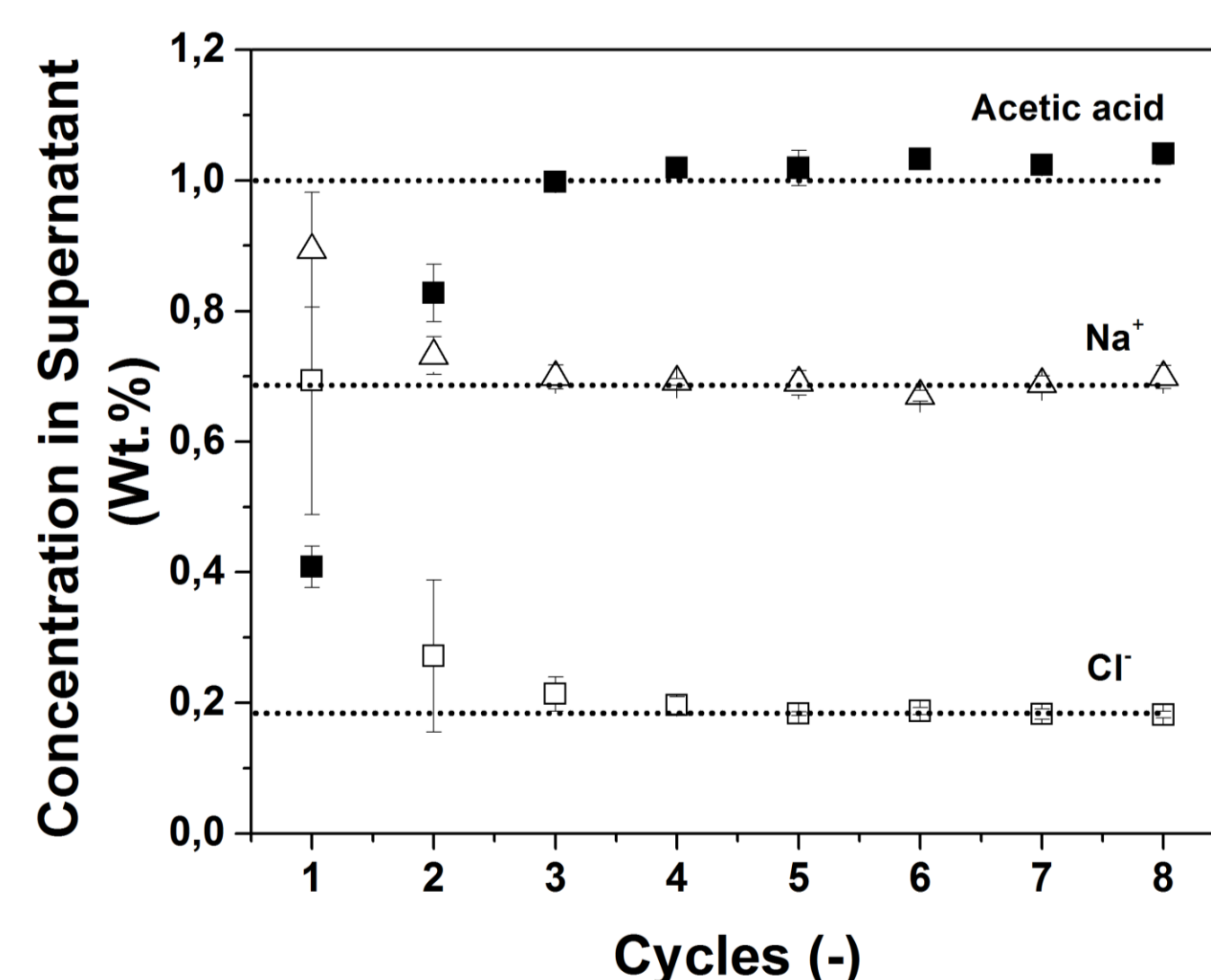


Figure 4: The concentration of acetic acid, sodium and chloride in supernatant (aqueous phase) over the 8 consecutive cross-current extractions. The dotted line is the concentration of the feed.

Conclusion:

After 3 cross-current extractions, no more extraction is seen and the complex coacervate is saturated. A capacity of acetic acid was obtained of $5 \cdot 10^{-3}$ - $5 \cdot 10^{-2}$ (g/g).

Recovery: To close the process, recovery experiments were done to recover the VFA from the complex coacervate. Several recovery methods were used; (a) Temperature Swing Back Extraction, (b) Short-Cut Distillation and (c) Short-Cut Vacuum Distillation.

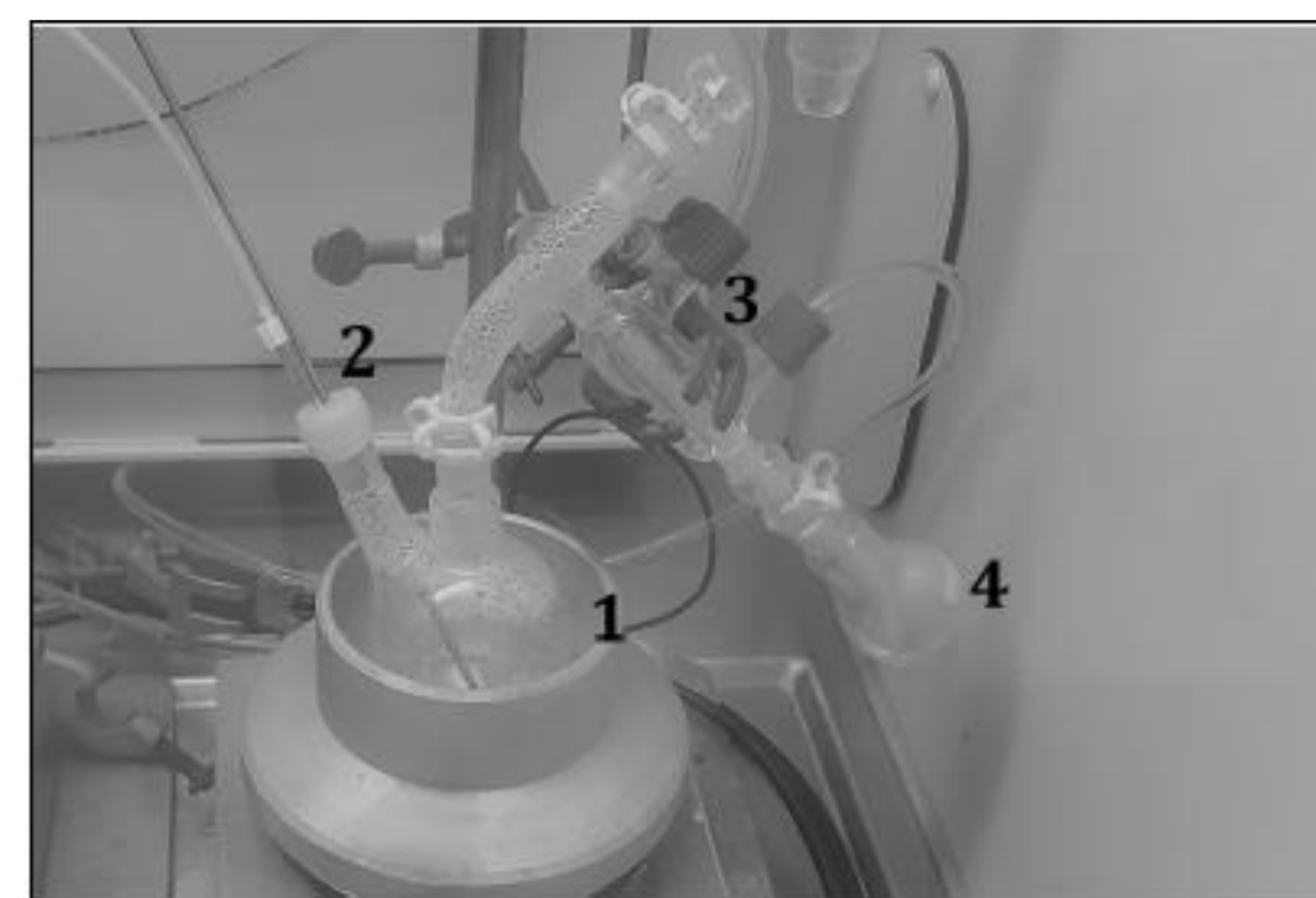


Figure 5: The short-cut distillation set-up with a (1) magnetic stirrer, (2) the flask with temperature probe and N_2 bubble, (3) the Liebig condenser and (4) a Erlenmeyer for distillate collection.

Conclusion:

It was observed that prior to distillation it was necessary to induce a homogenous phase by addition of salt or pH-swing for an adequate recovery. Hence, (a) via Temperature Swing Back Extraction only 9 % could be recovered.

(b) Short-cut Distillation was inadequate due to degradation of the polyelectrolytes at higher temperatures. Hence, Short-cut vacuum distillation was required.

The combination of homogenization of the complex coacervate and vacuum distillation resulted in a recovery of (c) 10-23% via pH-swing and 88% via the addition of salt.

Acknowledgements:

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