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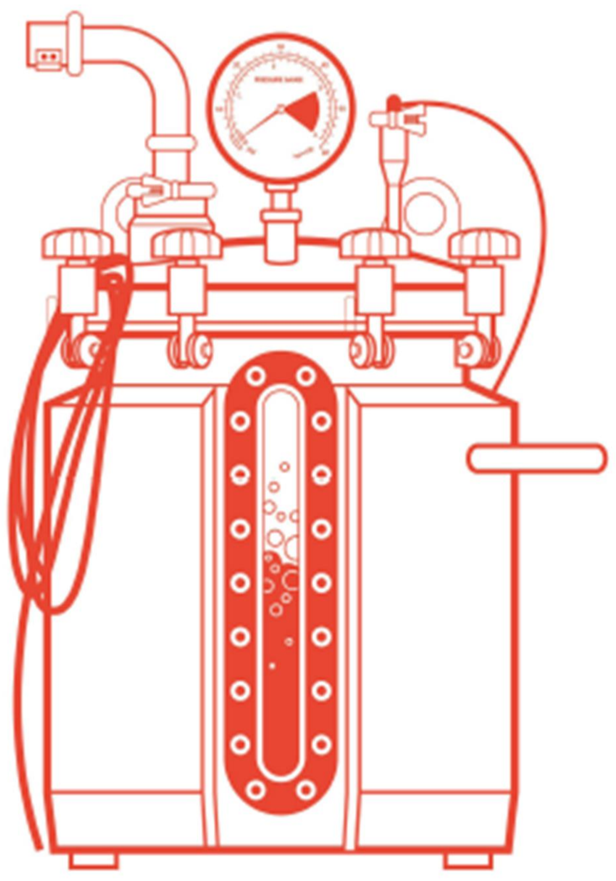

Development of setup to study electrostatic discharges

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Bachelor's-Thesis, Chemical and bioprocess technology

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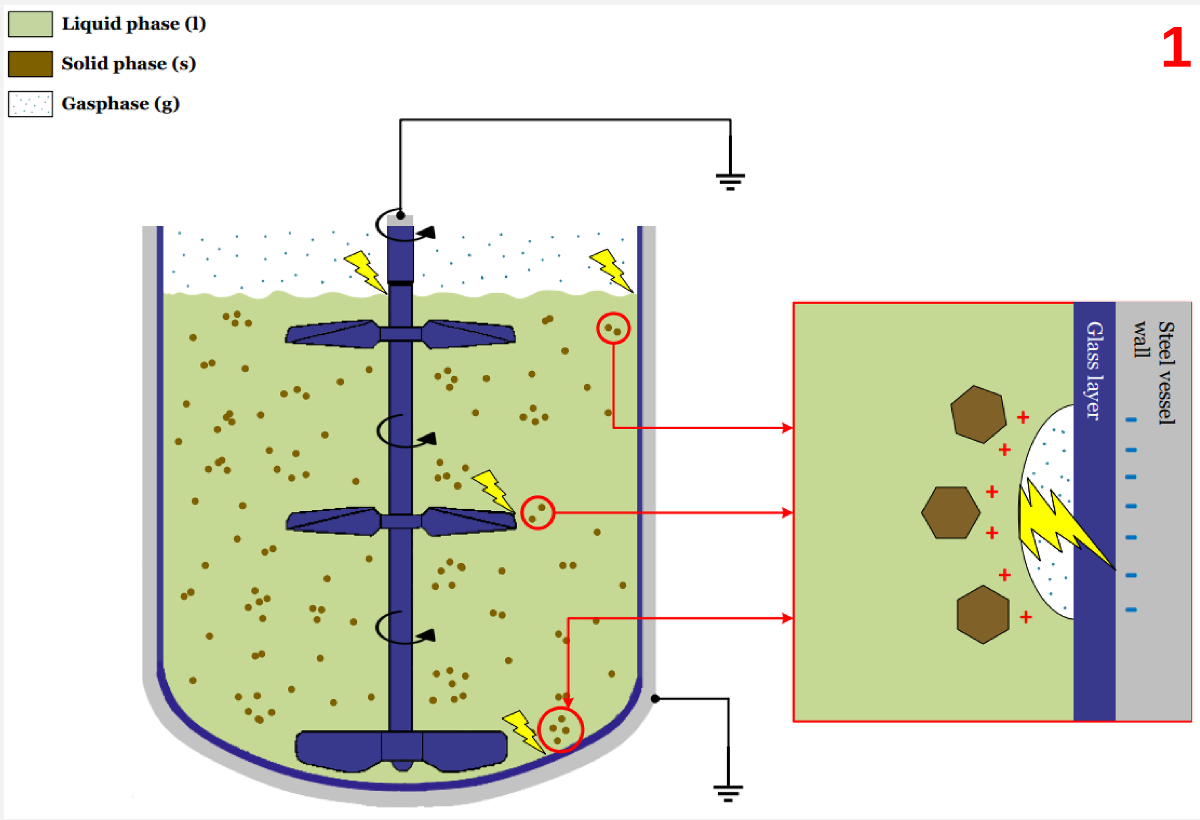
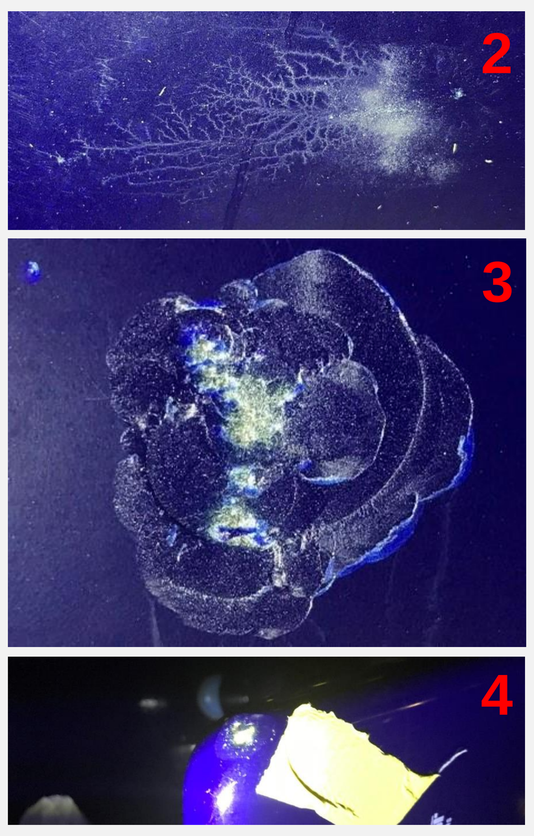
I.ABSTRACT

Two glass lined reactors in a launch platform facility operated by Syngenta have been damaged during a crystallization-process of an organic compound due to electrostatic discharges. The goal of this thesis was to design and commission a unique setup to measure charges and currents generated by such suspensions in a laboratory-scale reactor. These measurements made it possible to then calculate and estimate resulting discharge energies. An improved and more sophisticated setup was then proposed for possible implementation in their own laboratories. With this novel setup, the electrostatic charging of stirred suspensions involving non-conductive solvents could be accurately measured in the context of a case study that involved the suspension that led to liner damages in the production facilities of Syngenta.

II.DISCHARGE MECHANISM AND DAMAGES

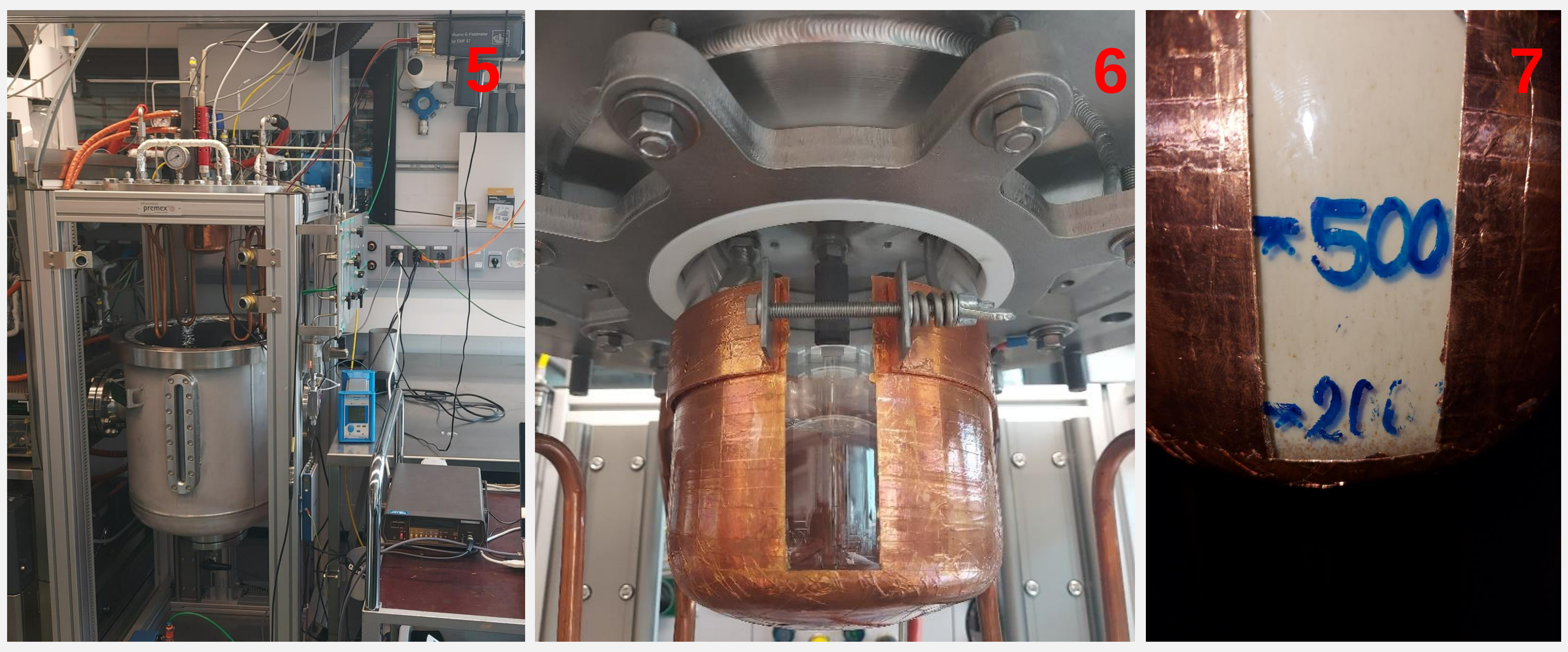
Discharges generally occur where the breakdown field strength of the surrounding medium is exceeded. Stirring liquids with low electric conductivity generate such high electric charges that brush discharges are formed. These discharges are predominantly generated along the surface of the Liquid and spread out to the vessel wall, baffle or stirrer. The part of the discharge with the highest energy will perforate the enamel at its weak point and produce a pore with reduced puncture resistance relative to its environment. The volume increase due to corrosion of the base material leads to flaking and the development of larger, noticeable holes. [1] Large interfacial areas between the two phases in suspensions where electrical double layers can form on the particle surfaces are especially prone to electrostatic charging when the solvent has a low electric conductivity.[2]

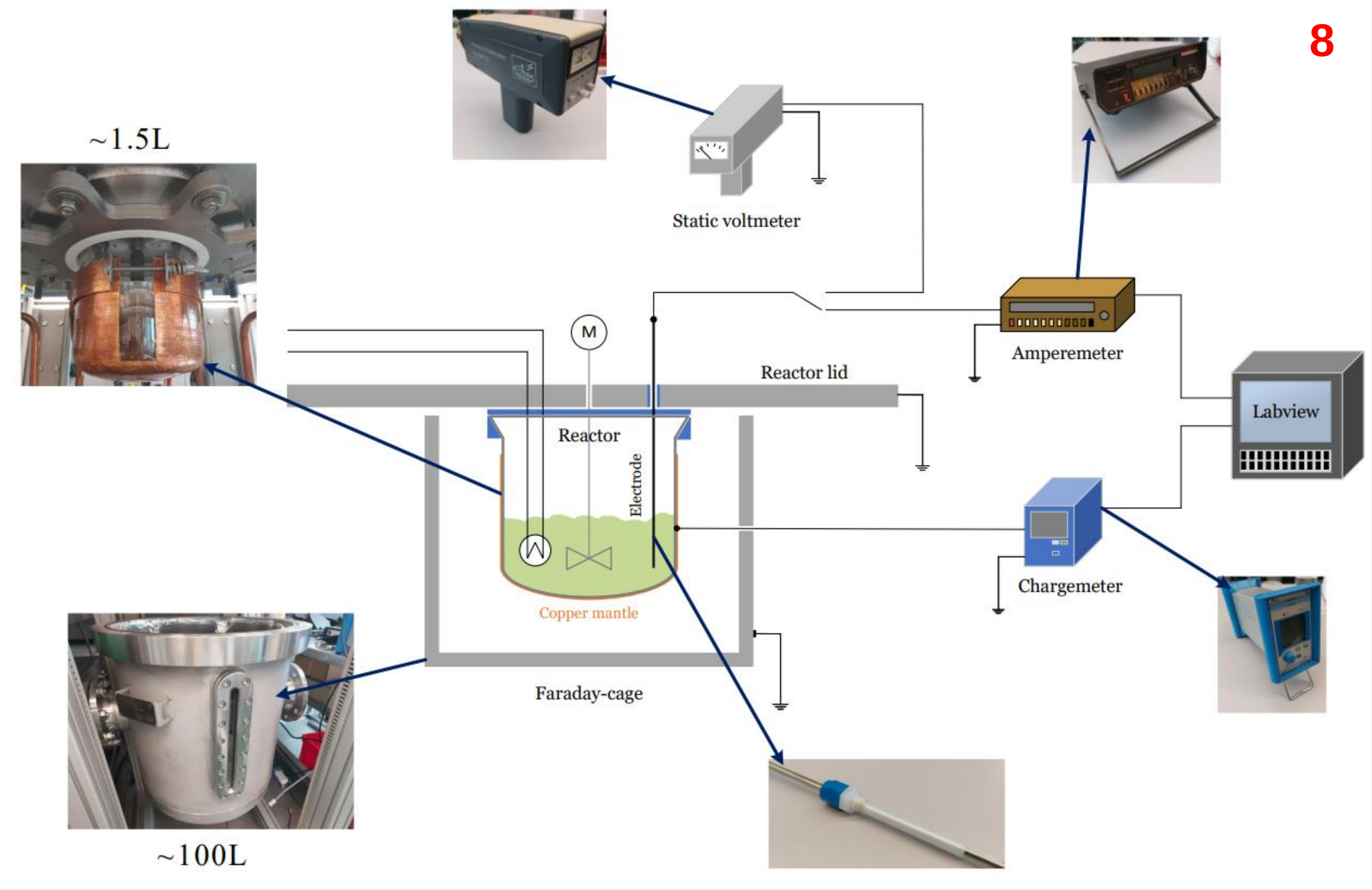




III.DESIGNED SETUP

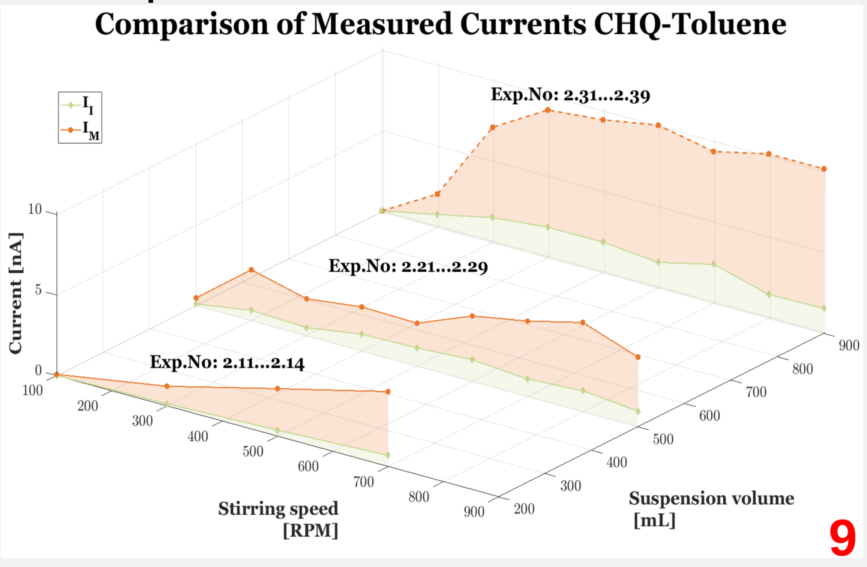
The setup consisted of a glass-reactor, enclosed in a faraday-cage. On the outside of the reactor, an electrically conductive layer was applied that allowed the connection of a charge meter. The interior of the reactor contained several components, most notably the stirrer and an electrode that was connected to an amperemeter. Alternatively, the electrode may be connected to a static voltmeter instead. The measurements could then be read, stored, and processed via LabVIEW.

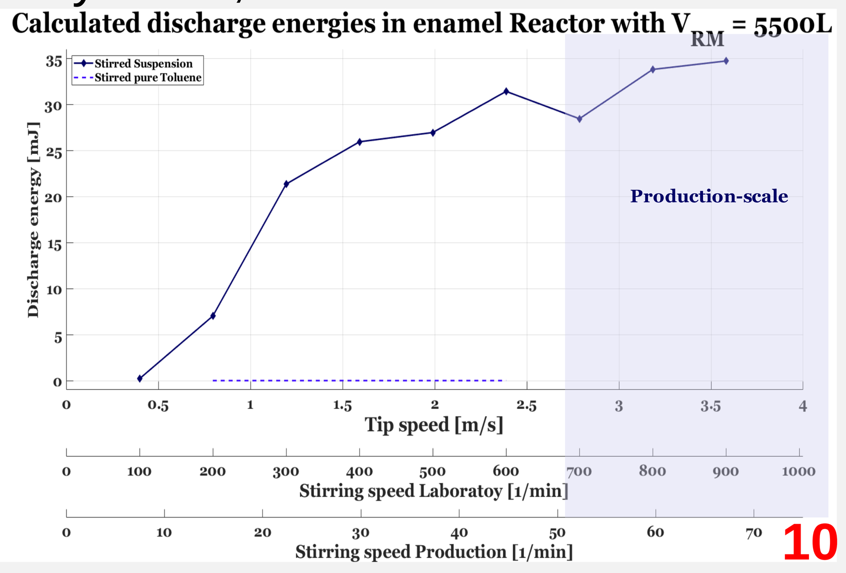




IV.RESULTS

The data shows that moderate stirring leads to high total charges, but more intense stirring results in comparably high currents. Crystals tend to remain at the reactor bottom when stirring is weak and charge is generated continuously. An increase led to although smaller total charges, but high currents because of the rapid charge separation processes that occur in the first few seconds of stirring. For the discharge energies, an increase in stirring speed correlated with an increase in discharge energies. For easier comparison, the main x-axis shows the tip speed of the stirrer blades and the corresponding stirring speeds of the laboratory and production scale vessel. There, speeds ranged from 50 up to 90 RPM, whereas the laboratory stirrer could only "depict" speeds of up to ~67RPM which corresponded to 900RPM in the laboratory scale, its technical limit.





V.CONCLUSION

The designed setup has, during the course of this work, proven itself to be able to effectively measure currents, charges and electric potentials that are caused by electrostatic charging in an agitated glass vessel.

Apart from being able to detect these small currents, charges and high voltages, their absolute values and the general course of plotted data seem to have a systemic behavior that can be interpreted (see **Figure 9**). A form of reproducibility between performed experiments and runs can be observed as well. Still, the total number of experiments that was carried out remains small at this point. Ultimately, the calculated discharge energies (see **Figure 10**) seem plausible from a relative point of view but are small in their absolute values and further testing and experimenting is needed. Overall, at this stage, it is possible to qualitatively describe the suspension investigated on the course of the case study regarding its charging behavior.

Figures:
1: Discharge mechanism in a glass lined vessel | **2…4:** Damages on glass liner |
5: Full view of Setup **| 6:** Glass reactor **| 7:** Stirred suspension in reactor
8: General schematic of setup
9: Measured currents
10: Calculated discharge energies

References:

[1] B. Maurer, "Damage to enamel on stirred apparatus triggered by static electricity discharges of material being stirred," Journal of Electrostatics, vol. 40–41, pp. 517–522, Jun. 1997, doi: 10.1016/S0304-3886(97)00096-X.
[2] G. Wypych and J. Pionteck, Handbook of antistatics, Second edition. Toronto: ChemTec Publishing, 2016.

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