

Refractive Index for Vanadium Redox Flow Battery Electrolyte States of Charge and Health Analysis

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Problem statement:

State of Charge (SoC) and State of Health (SoH) are must to be known parameters of the Vanadium Redox Flow Battery (VRFB) for correct exploitation. However, during the VRFB operation, non-linear imbalance processes occur altering most of the physico-chemical properties of the electrolyte introducing significant inaccuracies in SoC/SoH-predictive models. Means physico-chemical methods are sensitive to both SoC and SoH; and such methods require regular recalibrations.

$$RI = f(\text{SoC}; \text{SoH}) \longrightarrow \text{SoC} - ? \text{SoH} - ?$$

Methodology: SoH estimation

Two core parameters were used for the VRFB electrolyte analysis: Refractive Index (RI) and Open Circuit Voltage (OCV). It was noted that, while at the same OCV, RI was shifting. RI shift at the same OCV was in a linear correlation with the SoH. RI was measured with an optical fiber at 1550 nm. Two experiments were performed: with an accelerated SoH decrease to validate a linear calibration in a wide SoH range; under real-life conditions.

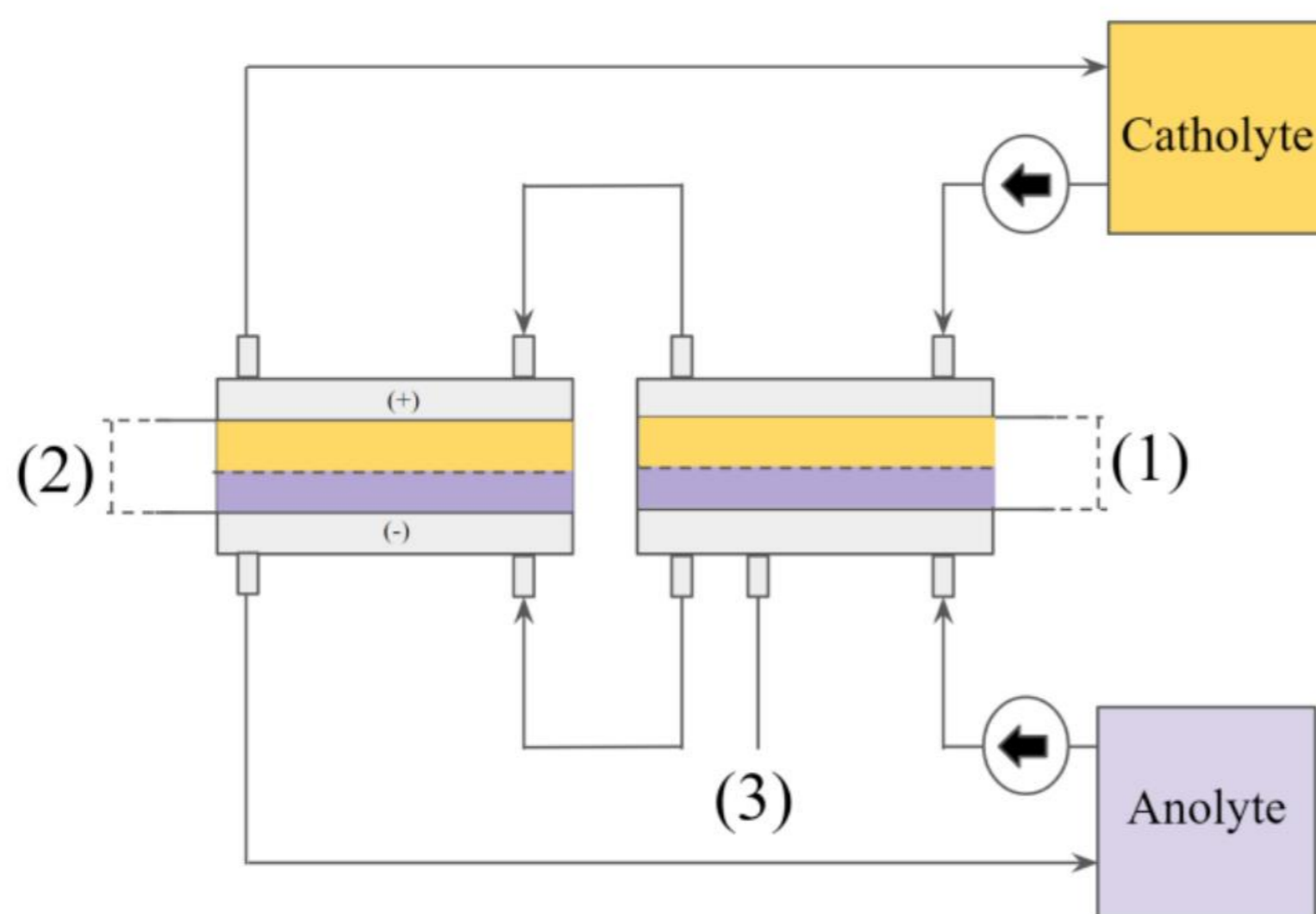


Fig.1 - General set-up scheme, 1 – OCV cell; 2 – VRFB; 3 – optical fiber inserted

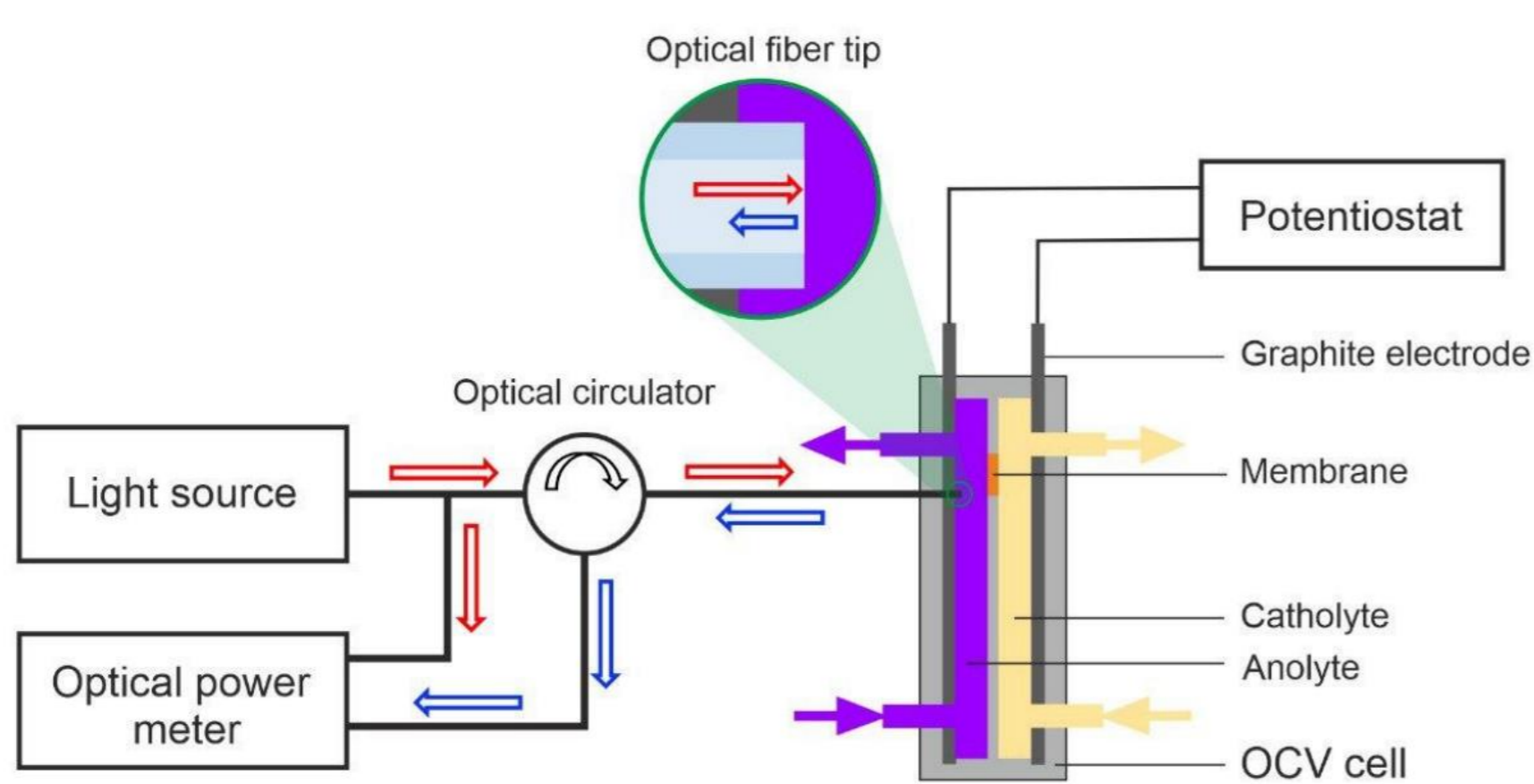


Fig.2 - SoH-measurement set-up scheme

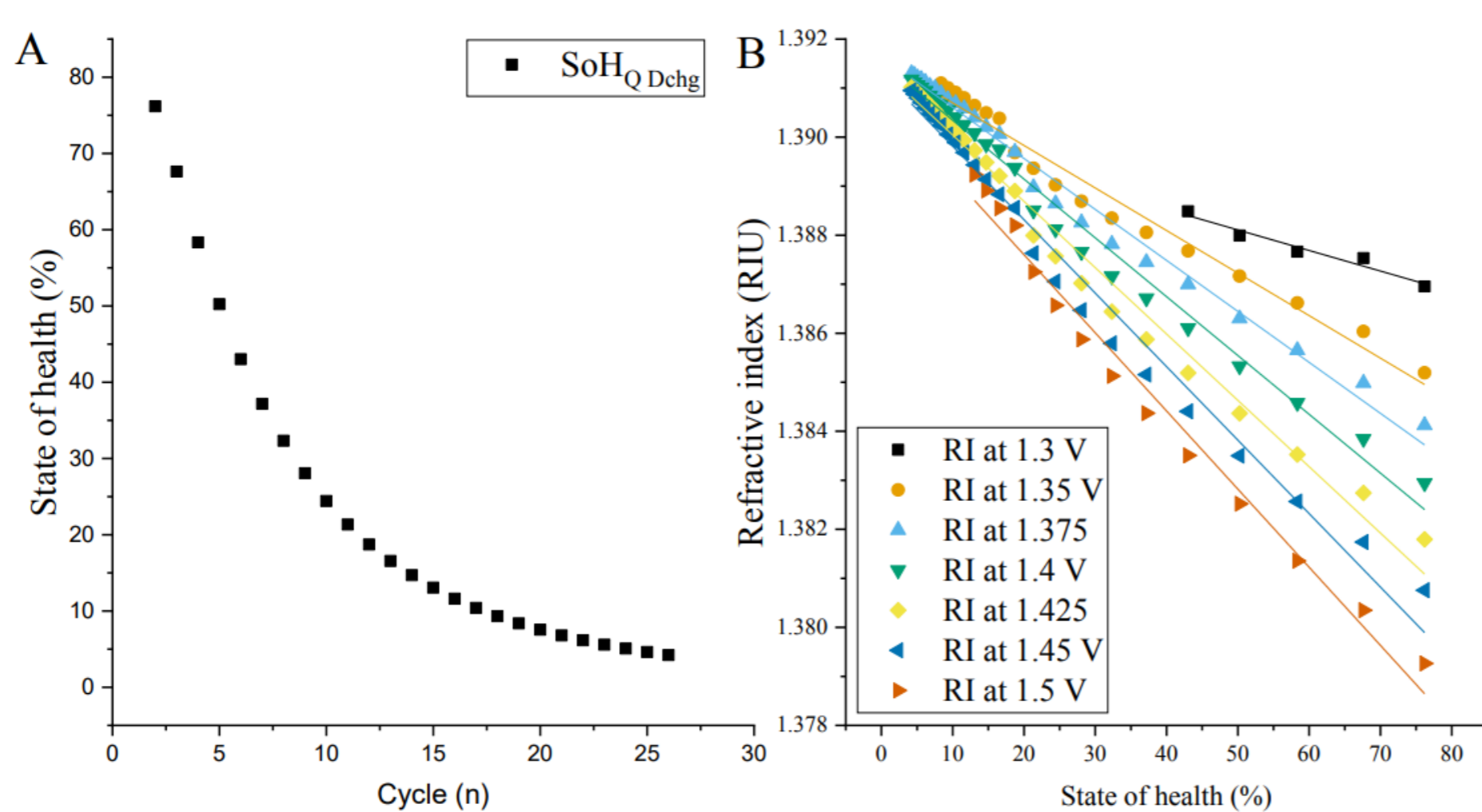


Fig.3 - Linear SoH interval in the extended range

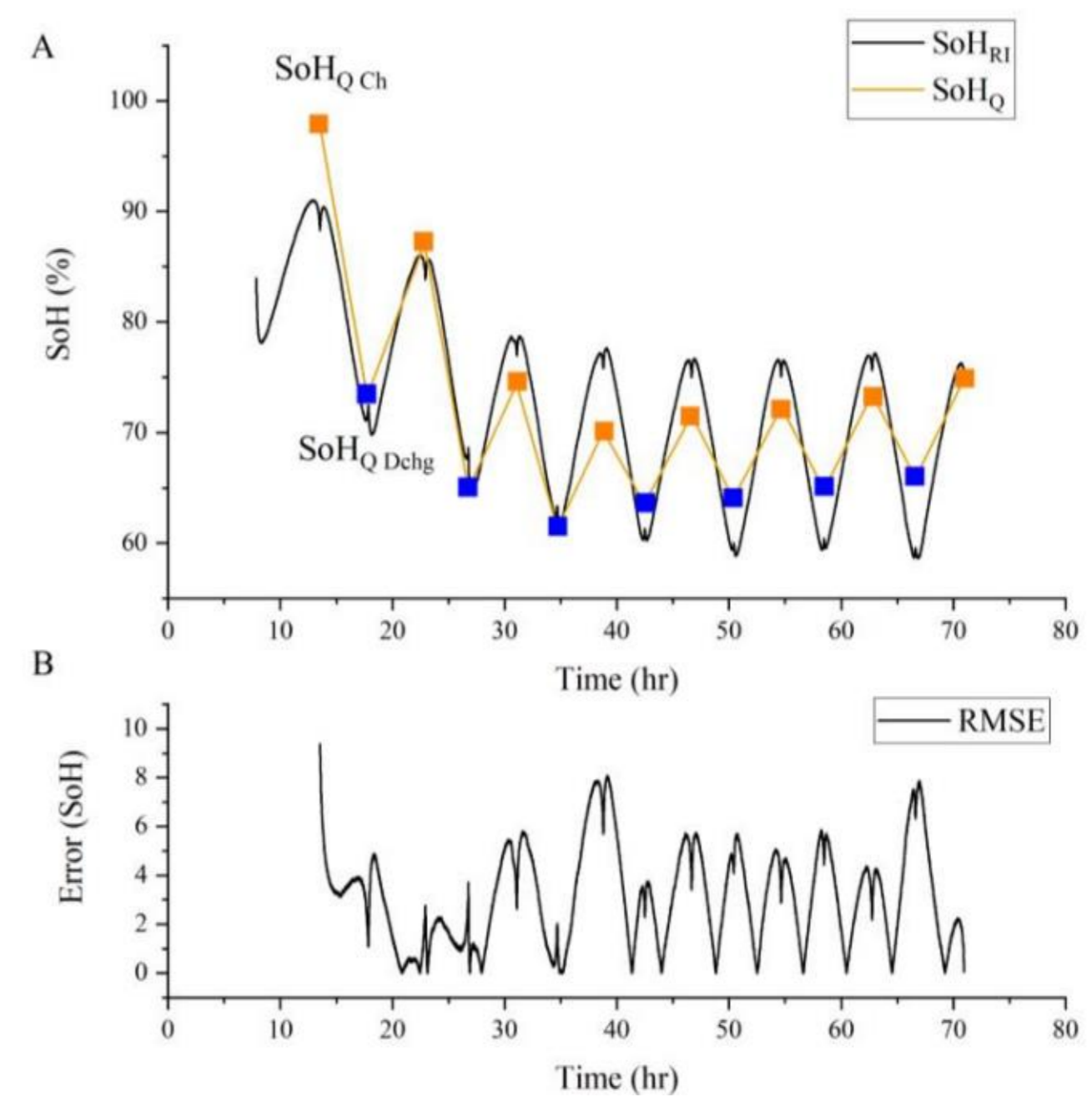


Fig. 4 - SoH prediction under real working conditions

Methodology: SoC estimation

Since RI is sensitive to both SoH and SoC, and we have defined the SoH effect, that effect can be subtracted and only the SoC effect accounted. Based on such approach, SoC was

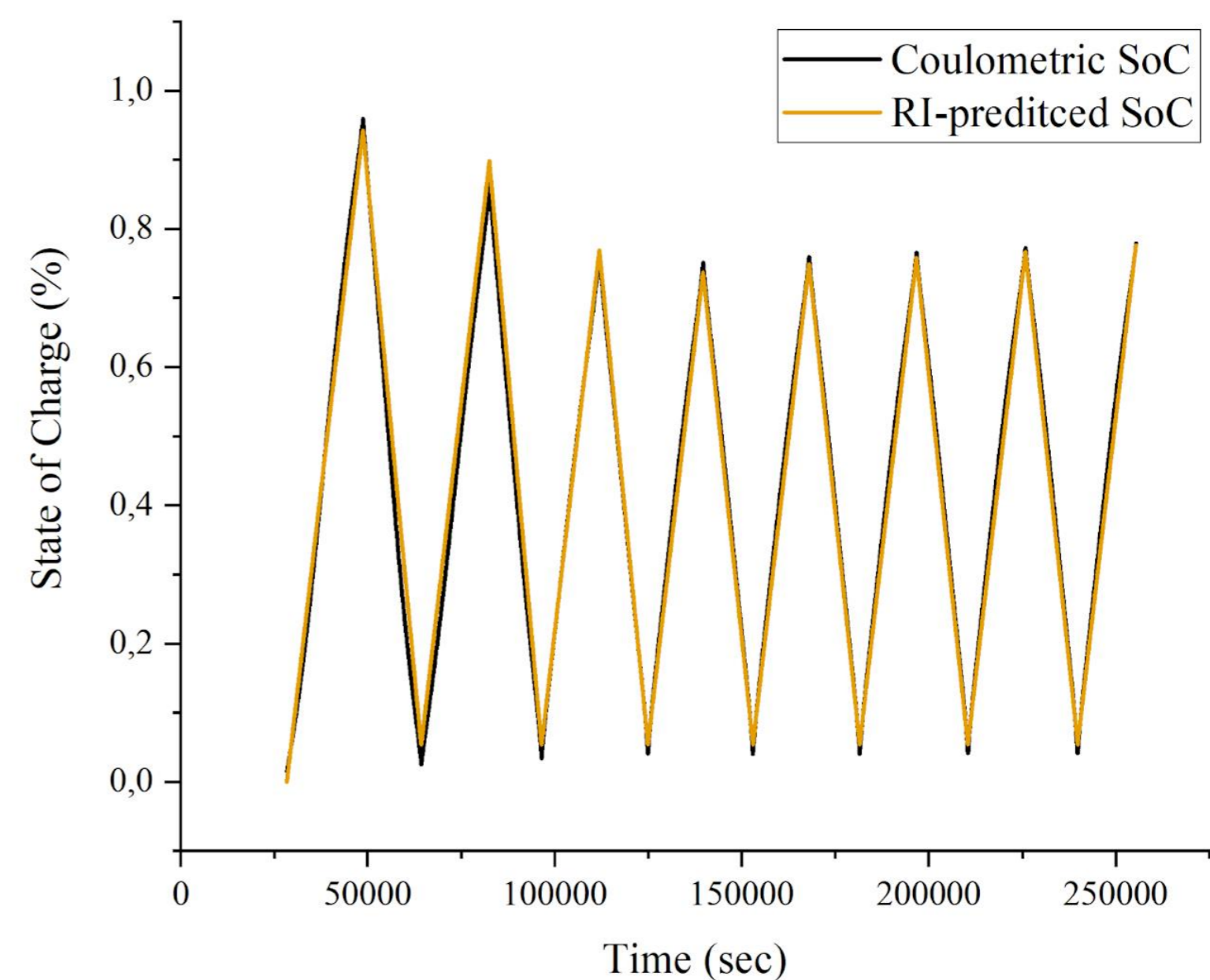


Fig. 5 – SoC predictions

Conclusions

RI is a perspective parameter that is used in many liquid systems for a quality control or analysis. Our research demonstrates a prospective of RI applicability towards liquid-electrolyte batteries like VRFB. Implementation of these approaches would allow improvements towards the VRFB operation accuracy.

References

V. Vlasov *et al.*, "In situ state of health vanadium redox flow battery deterministic method in cycling operation for battery capacity monitoring," Nov. 2023, doi: 10.1016/j.jpowsour.2023.233600.