School of Engineering
Department of Chemical Engineering
NCE – Nanomaterials, Catalysis, Electrochemistry
Professor Nathalie Job

PhD offer: Li-ion battery optimization & monitoring

Context and goal

In the framework of a collaborative F.R.S.-FNRS research project, the Department of Chemical Engineering recruits a PhD student in Engineering. The research will be conducted in direct collaboration with the University of Brussels (ULB - Department of Control Engineering and System Analysis, SAAS), where a post-doctoral researcher will be in charge of the project development.

The aim of the project is to **develop safer and long lasting lithium-ion batteries by combining tools from mathematical modeling, electrochemistry and control theory**. The resulting batteries can be used in stationary storage applications involving *e.g.* photovoltaic panels and associated converters. Thus, a microgrid relying on standalone energy capture and storage can be devised. Three main research directions will be considered to address this problem.

First, we will develop **a method for the optimal design of a battery cell** relying on a specific chemistry ($Li_4Ti_5O_{12}$/$LiFePO_4$, aka LTO/LFP), and on a specific 'greener' processing method (aqueous preparation pathway and spray-coating). On the one hand, the choice of chemistry and processing should result in more stable, environmentally benign and cost-effective lithium-ion batteries than the classical graphite/$LiCoO_2$ (LCO) batteries. On the other hand, the method for optimal design will rely on a mathematical model of the battery and on numerical optimization methods to reach the best performance by appropriately sizing the battery. Such an approach can save a considerable amount of resources for battery development in terms of materials and man-hours if compared to more traditional approaches based exclusively on experiments.

Second, we will perform **an experimental analysis and determine a mathematical model of the degradation evolution** in LTO/LFP batteries. The model will describe the evolution of battery aging in function of the operating conditions.

Third, we will develop **a battery management system (BMS) able to monitor the state-of-charge (SOC) and the state-of-health (SOH)** of such batteries when they are used in series/parallel arrangements in order to reach the required voltage/power levels. Indeed, the cells within a battery pack exhibit discrepancies due to manufacturing heterogeneities and different thermal stresses. Determining and monitoring the weakest cell in terms of capacity must be performed in order to avoid cell over(dis)charge. Although the methodology for battery optimization and monitoring will be developed for a specific battery chemistry, it is expected to be adaptable to other types of lithium-ion batteries as well.

Role of the PhD student

The main role of the PhD student will be to design, build and test the LTO/LFP batteries/packs in order to generate data that can be used for the battery optimization by the SAAS group (ULB). The work also includes post mortem analyses of the elements to detect the reason for cell degradation/failure. Since the work will be performed in close collaboration with the control-oriented researchers at ULB, it is expected that the student also participates to the modelling and BMS development, and thus acquire knowledge on these topics as well.

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Information

- *General:* The recruit will be registered as PhD student in Engineering at ULiège (Belgium). The work will mainly take place in Liège (Department of Chemical Engineering – Nanomaterials, Catalysis, Electrochemistry), with frequent visits to ULB (~100 km from ULiège).
- *Student profile:* Master in Engineering or in Sciences (preferably with a strong formation in (electro)chemistry, materials and physics)
- *Language:* fluent English (mandatory)
- *Duration:* 4 years
- *Start:* Fall 2020
- *Application:* please send a detailed CV and a motivation letter to Nathalie.Job@uliege.be
- *Application deadline:* June 30th 2020
- *Supervisor:* Prof. Nathalie Job - Department of Chemical Engineering – Nanomaterials, Catalysis, Electrochemistry