# The NLV: A new ultra-fast charging technology for lithium ion batteries

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One of the limiting factors of the electric vehicle (EV) market integration is a long charging time. High energy density batteries are needed to insure a long driving range. However, high energy density batteries do not sustain continuous high current flow to fast charge them because of overheating and possible lithium plating on the graphite anode. High power density batteries on the other hand, can be fast charged but the lack sufficient driving range, which is highly required for EV. Currently, there is a tradeoff between energy and power when the charging method is based on one- or multi-stage constant current (CC).
Here we show that changing the charging method from CC-based to multi-stage constant voltage (MSCV)-based method elevates the issue between high-energy and high-power density batteries. The newly developed method for ultra-fast charging is coined as Nonlinear Volatmmetry (NLV).

In NLV a series of ascending voltage steps are applied while the charging current response, which is not constant, is analyzed. We established a relationship between the applied voltage and the flowing current enabling a transfer from one voltage plateau to the next voltage plateau. NLV enables cutting the charging time recommended by the battery manufacturer by 2x to 5x according to the battery chemistry, state of health
and design.

Figure 1 shows a typical voltage and current profiles during charging a battery from 0 to 100% in about 15 min. For such a battery, the standard charging time with CC-based method is 60 minutes. Figure 2 shows the corresponding temperature profile, which did not exceed 42C.

We then successfully applied NLV to several battery packs ranging for 20V to 60V. The 5 to 15 cells in series-based packs behaved like single cells regarding the charging time and temperatures with the only differences lying on the voltage profiles. We also applied NLV to several cells arranged in parallel. A combination of cells in series and in parallel opens the NLV application to larger battery packs for EV.

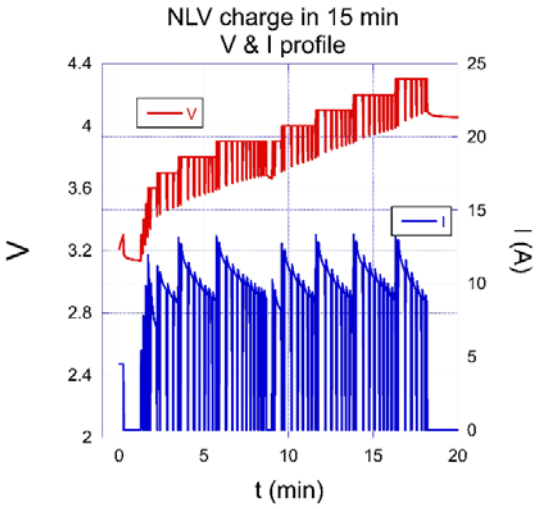


Figure 1: Voltage and current profile during NLV charging in 15 minutes.

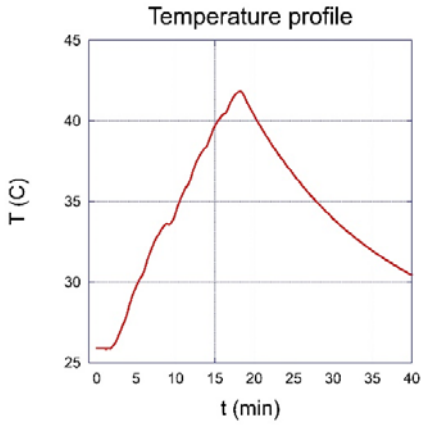


Figure 2: Temperature profile during NLV charging in 15 minutes.

Professor Rachid Yazami is a graduate of the Grenoble Institute of Technology with major in materials science and electrochemistry. He is the inventor of the graphite anode used in current lithium-ion batteries. Yazami has over 40 years long in academic and applied research activity relating to batteries. He is the inventor of 180 patents according the WIPO website. Currently, he is the founding director of KVI Pte Ltd in Singapore which develops battery management methods and systems using artificial intelligence

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