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EDITORIAL
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Editorial: Advanced Battery Thermal Management Systems

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Editorial on the Research Topic

Advanced Battery Thermal Management Systems

A massive number of lithium ion (Li-ion) batteries are used in electric vehicles and the number is still growing rapidly. Li-ion batteries are sensitive to temperature—they likely degrade in an over-cold or an over-hot environment. Battery thermal management systems (BTMSs) are designed to control the battery temperature within the optimal range between 20 and 55°C. Thermal management is one important part of battery management systems. A good BTMS allows researchers to improve the performance, extend the life, and enhance the safety of a battery. We launch this Research Topic to collect the latest technologies and design methodology on BTMSs.

Three papers have been published in this issue.

Yang et al. designed a semiconductor refrigeration system for a 48 V Li-ion battery pack which often operates at high discharge/charge rates, as shown in **Figure 1A**. A thermal model of the BTMS was also developed for this semiconductor-based BTMS. This BTMS is integrated with air cooling, limiting the maximum temperature to less than 40°C, as long as the temperature difference is less than 1.6°C. The semiconductor-based BTMS is effective when the battery temperature and discharge rate are high.

Wang et al. applied a flat heat pipe (FHP) to a BTMS, utilizing the extremely high thermal dissipation ability of the FHP to remove the heat from the battery, as well as to improve the temperature homogeneity among battery cells. The BTMS structure is presented in **Figure 1B**. A thermal network model was also developed for this BTMS and the simulation agreed with the experiment data. The thickness, porosity, and particle diameter of a sintered wick on the thermal performance of the battery was investigated and the FHP was optimized. An FHP allows a radiator to be placed aside the battery pack as a condensation sector, making the battery pack compact.

Luo et al. designed a novel direct liquid cooling BTMS. With a unique structure shown in **Figure 1C**, the BTMS can be used for cylindrical battery cells with water as the thermal fluid, without worrying about the potential risks of the electric conductivities of water. A numerical model was developed and validated with the system. They investigated the effects of the coolant flowrate and suggested a high flowrate (>500 mL/min) is needed for the discharge at a rate above 3C of a 20-cell module. Multiple inlets were also suggested to improve the temperature uniformity.

These studies have shown new prototypes of battery cooling with semiconductors, heat pipes, and direct liquid cooling, which could provide alternatives for thermal management in commercial battery modules.

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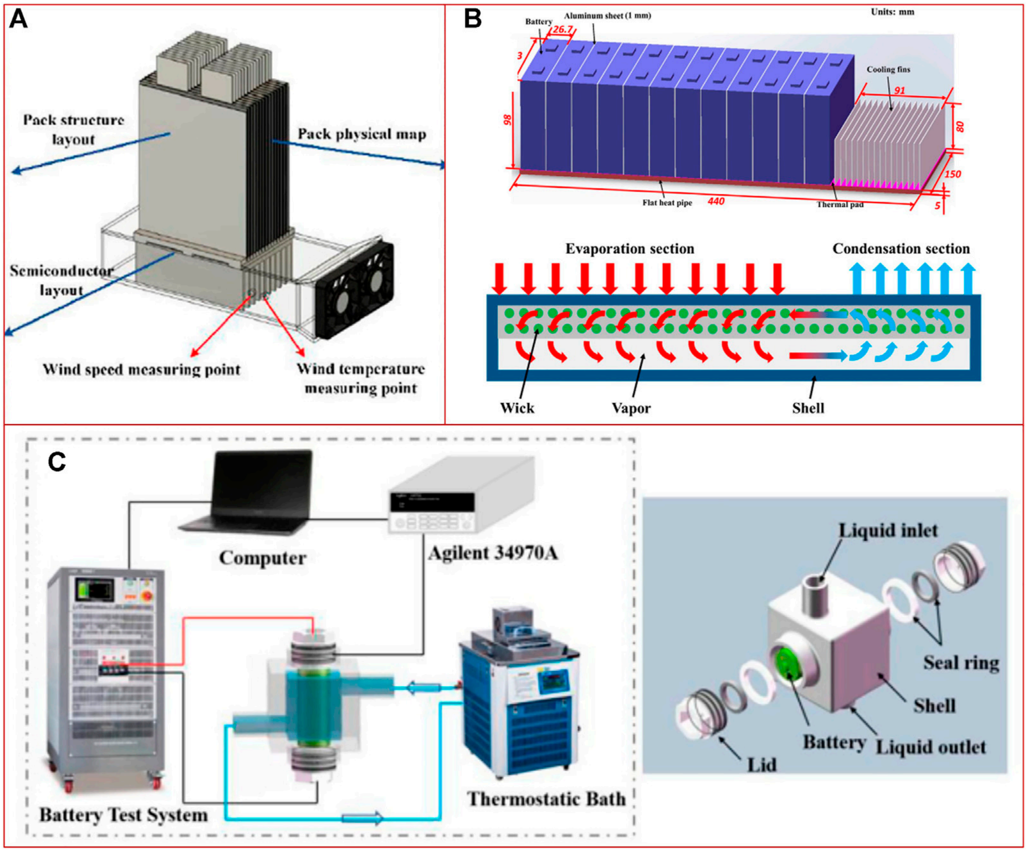

FIGURE 1 | Illustrations of a BTMS structure. **(A)** A semiconductor and air cooling by Yang et al.; **(B)** A flat heat pipe and air cooling by Wang et al.; **(C)** Immersion water cooling by Luo et al.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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