Nickel-cobalt-aluminum batteries nca france

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Due to the economic value of the materials contained within spent LIBs and the volume of waste predicted in the coming years, the most economical and environmentally friendly option is to reuse or to recycle them. This is even more important considering that 2022 has seen the first ever increase in LIB pack prices since records began in 2010 [24]. Such increases are primarily due to rising raw material and battery component prices and the increasing inflation.

To understand the supply and safety risks associated with the materials used in LIBs, it is important to consider the various active cathode chemistries of the numerous LIBs currently available. LIBs currently on the market use a variety of lithium metal oxides as the cathode and graphite as the anode [29].

The next LIB emerged in 1996 with a cathode made of lithium manganese oxide ($LiMn_2O_4$, LMO) [23]. Replacing cobalt in the cathode with nickel and manganese does make LMO cheaper than LCO but has resulted in a lack of cycling stability at high temperatures [46].

Similar to NMC is the lithium nickel cobalt aluminum oxide cathode ($LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$, NCA). NCA also has a high specific energy, power, and life span, but it is more expensive than NMC [31].

Most of the focus from recyclers is extracting the valuable metals such as copper, nickel, and cobalt [40] contained within the active cathode material. Despite this, the active cathode material only makes up a maximum of 35% of a LIBs" relative weight, as seen in Fig. 9.1. Pouch cells can weigh between 75 and 225 g, depending on the battery cathode chemistry.

Lithium-ion cells come in three principal shapes and sizes: cylindrical, pouch, and prismatic. All three "form factors" are employed in the larger applications of LIBs including EVs and battery energy storage systems (BESS). In an EV pack, the cells are arranged in series, parallel, or mixed configurations to form a module.

Each module will also have its own electrical and thermal control components [38]. The modules are then connected in series, parallel, or a combination of the two, to form a battery pack. The modules can be mechanically locked into place or welded or glued together, which is a considerable disadvantage in their manufacturing, as it makes them particularly difficult to disassemble. The packs themselves are housed in a plastic or metal container, also containing a whole pack battery and thermal management systems.

A LIB"s active components are an anode and a cathode, separated by an organic electrolyte, i.e., a conductive salt ($LiPF_6$) dissolved in an organic solvent. The anode is typically graphitic carbon, but silicon has emerged in recent years as a replacement with a significantly higher specific capacity [51]. The inactive components include a polymer separator, copper and aluminum current collectors, as well as a metal or plastic casing.

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The majority of materials that are constrained by resource limitations are those contained within the cathode, as well as the electrolyte due to its lithium content [35]. The majority of LIBs on the market today have cathodes which include lithium, cobalt, nickel, and manganese due to their high energy densities. Table 9.1 shows an estimate of the amount of these metals, in kilogram required per kilowatt-hour for five popular cathode materials.

Due to this, cobalt markets are volatile, rising from $31,000 per ton in 2012 to $93,000 per ton in 2018, with another peak in 2022 [2300, 28]. The volatility is well demonstrated in Fig. 9.3. This increase resulted in a 5-64% increase in cathode material costs per technology, proving the high dependence on raw materials in the industry [46]. Moreover, the supply risk score of cobalt has risen sharply from 49 in 2007, meaning the element was uncritical, up to 60 in 2017, making it the most critical element contained within battery cathodes [46].

Cobalt plays an important role within the battery chemistries, providing high energy densities and stable batteries, and so it is unlikely that cobalt will be eliminated from LIB cathodes in the near future [2]. This benefits the recycling industry as cobalt is the main driver of the revenue produced from pyrometallurgical and hydrometallurgical recycling. With appropriate recycling facilities and further development, the industry can move away from mined cobalt and begin to use recycled cobalt from spent LIBs.