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Recycling and disposal of lithium batteries: An economical and environmental approach (Article)

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Abstract

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The adoption of lithium-ion battery technology for electric vehicles/hybrid electric vehicles (EV/HEV) has recently received attention worldwide. The price of cobalt (Co) and lithium (Li) has increased due to the production of EV/HEV. A used lithium battery is a valuable source of active metals (Co, Li, and Al) and the optimal way of extracting these metals from this waste is still studied. The focus of this paper is to recover active metals using the hydrometallurgical method on a laboratory scale with a 48.8 Wh battery to reveal economic and environmental benefits. Calcination of extracted active metals as pre-thermal treatment has been conducted at 700°C to remove the organic compounds from the surface of active metals. The experiment has been conducted and the result shows that the recovery of active metals (cathode) is 41% of the cell cathode and 8.5% of the cell anode materials, which represent 48.8% and 23.4% of the cathode and anode cell material price, respectively. By recycling about 47.34% of the battery active metals, emissions can be reduced by 47.61% for battery metal production and 60.7% for disposal transportation of the used battery. The total emission can be reduced by about 52.85% by recycling the active metals in used batteries.

Author keywords

Calcination Economics and environmental values Electro-chemistry Li-ion battery Recycling

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1 (2011)
<http://www.reduse.org/en/blog/lithium-extraction-chilean-north>

2 Habashi, F.
(1997) *Principle of Extractive metallurgy*, 4. Cited 2 times.
Lithium. Wiley-VCH, Weinheim, 1997

3 William, T.
(2010) *How Much Lithium does a Lilon EV battery really need?-Meridian International Research France*
<http://www.meridian-int-res.com/>

4 Linda, G.
(2009) *Lithium Ion Battery Recycling Issues*, Linda Gaines, Argonne National Laboratory
Retrieved date: 21/5/09

5 Lain, M.J.
Recycling of lithium ion cells and batteries

(2001) *Journal of Power Sources*, 97-98, pp. 736-738. Cited 96 times.
doi: 10.1016/S0378-7753(01)00600-0

View at Publisher

6 Li, J., Zhao, R., He, X., Liu, H.
Preparation of LiCoO₂ cathode materials from spent lithium-ion batteries

(2009) *Ionics*, 15 (1), pp. 111-113. Cited 24 times.
doi: 10.1007/s11581-008-0238-8

View at Publisher

7 Rahman, A., Afroz, R.
Lithium battery recycling management and policy

(2017) *International Journal of Energy Technology and Policy*, 13 (3), pp. 278-291.
doi: 10.1504/IJETP.2017.084497

View at Publisher

8 Ferreira, D.A., Prados, L.M.Z., Majuste, D., Mansur, M.B.
Hydrometallurgical separation of aluminium, cobalt, copper and lithium from spent Li-ion batteries

(2009) *Journal of Power Sources*, 187 (1), pp. 238-246. Cited 111 times.
doi: 10.1016/j.jpowsour.2008.10.077

View at Publisher

9 Chagnes, A., Pospiech, B.
A brief review on hydrometallurgical technologies for recycling spent lithium-ion batteries

(2013) *Journal of Chemical Technology and Biotechnology*, 88 (7), pp. 1191-1199. Cited 62 times.
doi: 10.1002/jctb.4053

View at Publisher

- 10 Paulino, J.F., Busnardo, N.G., Afonso, J.C.
Recovery of valuable elements from spent Li-batteries

(2008) *Journal of Hazardous Materials*, 150 (3), pp. 843-849. Cited 100 times.
doi: 10.1016/j.jhazmat.2007.10.048

View at Publisher
-

- 11 Nan, J., Han, D., Zuo, X.
Recovery of metal values from spent lithium-ion batteries with chemical deposition and solvent extraction

(2005) *Journal of Power Sources*, 152 (1-2), pp. 278-284. Cited 159 times.
doi: 10.1016/j.jpowsour.2005.03.134

View at Publisher
-

- 12 Xia, Z.-D., Xie, X.-Q., Shi, Y.-W., Lei, Y.-P., Guo, F.
Recycling cobalt from spent lithium ion battery

(2008) *Frontiers of Materials Science in China*, 2 (3), pp. 281-285. Cited 4 times.
doi: 10.1007/s11706-008-0049-x

View at Publisher
-

- 13 Kang, J., Senanayake, G., Sohn, J., Shin, S.M.
Recovery of cobalt sulfate from spent lithium ion batteries by reductive leaching and solvent extraction with Cyanex 272

(2010) *Hydrometallurgy*, 100 (3-4), pp. 168-171. Cited 95 times.
doi: 10.1016/j.hydromet.2009.10.010

View at Publisher
-

- 14 Lupi, C., Pasquali, M.
Electrolytic nickel recovery from lithium-ion batteries

(2003) *Minerals Engineering*, 16 (6), pp. 537-542. Cited 47 times.
<http://www.journals.elsevier.com/minerals-engineering/>
doi: 10.1016/S0892-6875(03)00080-3

View at Publisher
-

- 15 Xu, J., Thomas, H.R., Francis, R.W., Lum, K.R., Wang, J., Liang, B.
A review of processes and technologies for the recycling of lithium-ion secondary batteries

(2008) *Journal of Power Sources*, 177 (2), pp. 512-527. Cited 263 times.
doi: 10.1016/j.jpowsour.2007.11.074

View at Publisher
-

- 16 Rahman, A., Razzak, F., Afroz, R., Mohiuddin, A.K.M., Hawlader, M.N.A.
Power generation from waste of IC engines

(2015) *Renewable and Sustainable Energy Reviews*, 51, art. no. 4528, pp. 382-395. Cited 7 times.
doi: 10.1016/j.rser.2015.05.077

View at Publisher
-

- 17 Adebayo, A.O., Ipinmoroti, K.O., Ajayi, O.O.
Dissolution Kinetics of Chalcopyrite with Hydrogen Peroxide in Sulphuric Acid Medium

(2003) *Chemical and Biochemical Engineering Quarterly*, 17 (3), pp. 213-218. Cited 42 times.

View at Publisher
-

- 18 Ferella, F., De Michelis, I., Vegliò, F.
Process for the recycling of alkaline and zinc-carbon spent batteries

(2008) *Journal of Power Sources*, 183 (2), pp. 805-811. Cited 55 times.
doi: 10.1016/j.jpowsour.2008.05.043

[View at Publisher](#)

- 19 Olubami, P.A., Borode, J.O., Ndlovu, S.
Sulphuric acid leaching of zinc and copper from Nigerian Complex Sulphide Ore in the presence of hydrogen peroxide

(2006) *Journal of the Southern African Institute of Mining and Metallurgy*, 106 (11), pp. 765-770. Cited 15 times.

- 20 Raymond, C.
(2005) *Physical chemistry for the bioscience, University Science Book, Sausalito California*
Retrieved date: August 2016
www.uscibooks.com

- 21 Rahman, A., Farhan, S., Ahmed, H., Hawlader, M.N.A.
Development of evaporative battery cooling system for EVs/HEVs
(2014) *International Journal of Electric and Hybrid Vehicle System, Inderscience*, 8 (2), pp. 233-240. Cited 3 times.

- 22 Rahman, A., Helmi, A., Hawlader, M.N.A.
Two-phase evaporative cooling battery thermal management system for electric vehicle
(2017) *International Journal of Automotive Technology*, 18 (3), pp. 72-882.

- 23 Rahman, A., Afroz, R., Alam, Z.
Development of electric vehicle: Public perception and attitude, the Malaysian approach

(2014) *World Review of Intermodal Transportation Research*, 5 (2), pp. 149-167. Cited 2 times.

<http://www.inderscience.com/browse/index.php>

doi: 10.1504/WRITR.2014.067231

[View at Publisher](#)

- 24 Dunn, J.B., Gaines, L., Sullivan, J., Wang, M.Q.
Impact of recycling on cradle-to-gate energy consumption and greenhouse gas emissions of automotive lithium-ion batteries

(2012) *Environmental Science and Technology*, 46 (22), pp. 12704-12710. Cited 62 times.

doi: 10.1021/es302420z

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