C O B A L T N E W S

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COMMENT

Christmas is almost upon us and this year's present seems to be an improving cobalt market. This is largely driven by the continued strong demand for rechargeable batteries but other sectors, such as superalloys, are also having a strong showing. Should be a very interesting 2017.

Cobalt is under an unprecedented level of attention from regulators in the EU and faces some real and disproportionate challenges in this area. Whilst the CDI recognises the legal CMR classification of 5-cobalt salts and has self-classified cobalt metal (all physical forms) as Carc1B through inhalation, the authorities in the EU seem determined to 'over' classify which could have a dramatic impact on market access for cobalt in the EU. Through our subsidiary, the Cobalt REACH Consortium Ltd (CoRC), we have spent some €25-30 Million on the science related to cobalt, only for this to be largely ignored by EU Regulators and Scientific Committees. A collaborative approach would pay huge dividends by avoiding overburdening both industry and regulators – we can live in hope.

Cobalt is also under scrutiny because a large proportion of cobalt units are mined in the DRC where there is a problem with unregulated Artisanal and Small Scale Mining (ASM) and illegal mining. The CDI represents responsible large scale mining (LSM) companies in this region who are in fact mining copper, from which cobalt is extracted as a by-product. Responsible LSM recognised over 20-years ago that closer attention needed to be paid to sustainable operating and so they already cover key issues in their Corporate Social Responsibility programmes. The ASM on the other hand is much more difficult to formalise and control, and this creates an undeserved reputational risk to responsible mining companies who provide meaningful and sustainable alternative livelihoods.

2016 First Half Production Statistics

Table 1 – CDI First Half 2016 Refined Cobalt Production Statistics (Tonnes)

Member companies		2010	2011	2012	2013	2014	2015	2016
Ambatovy, Madagascar		0	0	0	1165	1405	1520	1587
BHPB/QNPL, Australia[(1)]		1043	1179	1283	1065	0	0	0
CTT, Morocco		729	910	688	780	606	882	833
Eramet France		181	191	167	172	146	88	76
Gecamines, DRC[(2)]		265	360	380	350	250	200	200
Glencore[(3)]:	Katanga, DRC	0	0	0	0	1000	1800	0
	Minara, Australia	0	0	0	0	1400	1600	1500
	Mopani, Zambia	0	0	0	0	0	0	0
	Nikkelverk, Norway[(4)]	1580	1404	1388	1600	1700	1500	1800
ICCI, Canada		1744	1838	1947	1558	1463	1709	1951
Freeport Cobalt, Finland (was OMG)		4157	4880	5345	4690	5284	4322	5472
Rubamin, India (Left CDI 2013)[(5)]		281	295	175	25	0	0	0
Sumitomo, Japan		1041	926	1246	1291	1753	1994	2209
Umicore, Belgium [(6)]		1325	1565	2131	2300	2958	3018	3164
Vale, Canada		290	1020	1025	1144	937	1090	927
Zambia [(7)]		1640	2325	2743	2583	2227	1326	1937
Total		**14276**	**16893**	**18518**	**18723**	**21129**	**21049**	**21656**

Notes: 1. 2009: BHPB 700mt Jan - Jul and Queensland Nickel Pty (QNPL) 1000mt Aug-Dec. See also Note 12
2. Estimated production; 3. Glencore joined CDI 2014 4. Previously reported as Xstrata, Norway
5. Rubamin joined CDI in 2009 and left in 2013; 6. Includes Umicore's global refined production
7. Chambishi Metals plc Zambia (ERG)

Production

In Table 1 we show the refined cobalt production from CDI members for the first six months of each calendar year from 2010 to 2016. Glencore joined as Full Members of the CDI in 2014 and so their tonnage now reports in Table 1. As a result, direct comparisons of total CDI Member production with the previous years are affected accordingly. As shown in the table, total production from CDI member companies

Non-Member companies	2010	2011	2012	2013	2014	2015	2016
China [(8)]	17181	17939	15296	17249	20460	26030	23483
India [(9)]	310	360	360	125	100	100	50
Kasese, Uganda	314	327	269	291	0	0	0
Katanga, DRC (See Glencore)[(10)]	1776	1298	1071	1000	0	0	0
Minara, Australia (See Glencore)[(10)]	1008	945	1110	1400	0	0	0
Mopani, Zambia (See Glencore)[(10)]	600	600	180	0	0	0	0
Norilsk, Russia[(11)]	1241	1205	1147	1224	1173	1053	1617
QNPL, Australia[(12)]					1177	1047	0
South Africa[(13)]	436	440	494	625	705	610	615
Votorantim, Brazil	655	732	846	796	700	700	400
DLA Deliveries	-8	0	0	0	0	0	0
Total	**23513**	**23846**	**20773**	**22710**	**24315**	**29540**	**26165**

Notes: 8. Excludes Umicore's refined production in China; 9. Excludes Rubamin between 2009 and 2013
10. From 2014 this reports as Glencore in Table 1; 11. Norilsk ceased to be a CDI member in 2009
12. QNPL ceased to be a CDI Member from 2014 and ceased to trade April 16
13. Estimates for RSA Jun production 2016

Table 3 – CDI First Half 2016 Total Refined Cobalt Availability (Tonnes)

	2010	2011	2012	2013	2014	2015	2016
CDI Members	14276	16893	18518	18723	21129	21049	21656
Others	23513	23846	20773	22710	24315	29540	26165
Total[(14)]	**37789**	**40739**	**39291**	**41433**	**45444**	**50589**	**47821**

Notes: 14. Total Supply does not include any estimates for producers not reporting their production

for the first half of 2016 was 21,656 tonnes which is slightly higher than the previous year. Please note that Umicore includes production from their Ganzhou Yi Hao subsidiary in China and this tonnage is therefore not included in the figure for China.

Table 2 summarises refined cobalt production from non-CDI producers together with any deliveries from the DLA stockpile, if any, as the stockpile for cobalt is relatively inactive currently.

As mentioned, refined production attributed to Glencore has moved into Table 1, so direct comparisons for non-member companies are affected accordingly.

Overall, production from non-CDI producer companies was 26,165 tonnes which represents a decrease of ~11% when compared to the same period in the previous year. This was largely a result of a ~10% decrease in refined production recorded by China when compared to the first half of 2015. We have no further information on any connotative stockpiles of cobalt that might exist in China (see the annual CDI statistics which appeared in the April 2012 edition of the Cobalt News). However, we are aware from general press coverage that metal stockpiles in China are being drawn down. As previously mentioned the Chinese refined production shown in Table 2 does not include Umicore's production in China, which is included in Table 1.

The DLA reports its figures slightly differently from the past and the figure shown is *the 'change in uncommitted inventory'* and should be similar to the old DLA *'delivery'* figure we had reported in previous years. There have been no sales over the period and therefore the DLA inventory at the end of June 2016 remains at 301 tonnes. It is understood that the DLA cobalt Basic Ordering Agreement sales program has been deactivated until further notice (DLA Strategic Metals news release of March 11, 2011).

The total availability of refined cobalt in the first half of the year from 2010 to 2016 is shown in Table 3. The figures show that overall availability in the first half of 2016 was 47,821 tonnes, some 5% lower than the same period in 2015, largely as a result of the decrease in Chinese refined production, coupled with lower production from Votorantim and the closure of QNI. This follows on from a ~11% increase when reporting these figures at this time last year. As in the past, we emphasise that the figures do not include production of refined cobalt from companies treating various cobalt-containing intermediate products and scrap that do not report their figures.

Demand

The CDI has published supply and apparent demand data in the WBMS/CDI "World Cobalt Statistics 2013-2015". The data were derived from worldwide import/export figures. The publication details apparent worldwide refined cobalt demand by geographical location. It can be purchased from either the CDI or WBMS. Please see website 'Publications' for details.

In 2015, apparent worldwide demand totalled around 87,000 tonnes, which is about 6% higher than the previous year. As mentioned, the publication can be purchased from either the CDI or the WBMS. See this website for details.

Price

The HG (LMB) price opened 2016 at US$10.30/lb (compared withUS$14.30/lb for 2015) and at the end of September was US$12.90/lb. The LG (LMB) price opened at US$10.30/lb (compared to US$14.15/lb in 2015) and at the end of September was US12.75/lb. The 2016 average HG price to end September is US$11.39/lb and for LG it is US$11.21/lb (the CDI takes the average bid/offer spread for both the HG and LG Metal Bulletin price quotation when calculating its average price). A particularly notable feature over the past two years is the narrowing of the spread between HG and LG as the demand for chemical grade cobalt continued to increase ahead of metal.

Cobalt has traded on the LME since February 2010 with the 3M contract which was joined by cash trading in May of that year. The average LME cash price for 2016 to end September is US$10.95/lb (the CDI takes the average daily bid/offer cash spread for cobalt and averages this over the period). The C-3 spread varied between a US$1,100/tonne contango and a US$252.5/tonne backwardation with an average spread for period of about US$24/tonne in contango.

Fungi recycle rechargeable lithium-ion batteries

Although rechargeable batteries in smartphones, cars and tablets can be charged again and again, they don't last forever. Old batteries often wind up in landfills or incinerators, potentially harming the environment. And valuable materials remain locked inside. Now, a team of researchers is turning to naturally occurring fungi to drive an environmentally friendly recycling process to extract cobalt and lithium from tons of waste batteries.

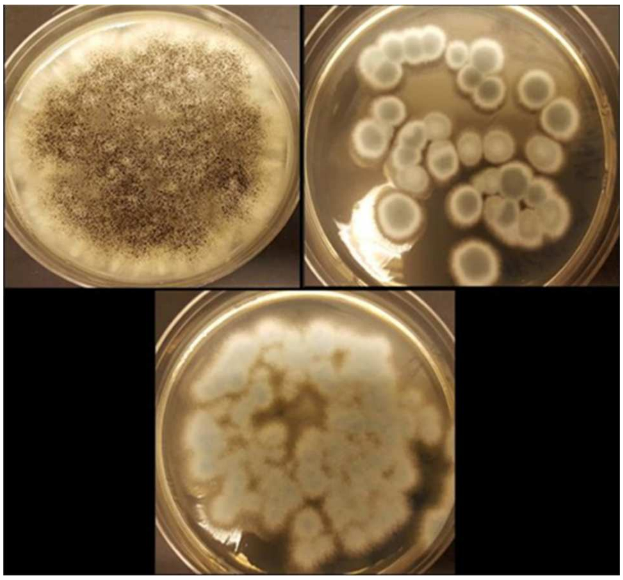
"The idea first came from a student who had experience extracting some metals from waste slag left over from smelting operations," says Jeffrey A. Cunningham, Ph.D., the project's team leader. "We were watching the huge growth in smartphones and all the other products with rechargeable batteries, so we shifted our focus. The demand for lithium is rising rapidly, and it is not sustainable to keep mining new lithium resources," he adds.

Although a global problem, the U.S. leads the way as the largest generator of electronic waste. It is unclear how many electronic products are recycled. Most likely, many head to a landfill to slowly break down in the environment or go to an incinerator to be burned, generating potentially toxic air emissions.

While other methods exist to separate lithium, cobalt and other metals, they require high temperatures and harsh chemicals. Cunningham's team is developing an environmentally safe way to do this with organisms found in nature -- fungi in this case -- and putting them in an environment where they can do their work. "Fungi are a very cheap source of labor," he points out.

To drive the process, Cunningham and Valerie Harwood, Ph.D., both at the University of South Florida, are using three strains of fungi -- *Aspergillus niger*, *Penicillium simplicissimum* and *Penicillium chrysogenum*. "We selected these strains of fungi because they have been observed to be effective at extracting metals from other types of waste products," Cunningham says. "We reasoned that the extraction mechanisms should be similar, and, if they are, these fungi could probably work to extract lithium and cobalt from spent batteries."

The team first dismantles the batteries and pulverizes the cathodes. Then, they expose the remaining pulp to the fungus. "Fungi naturally generate organic acids, and the acids work to leach out the metals," Cunningham explains. "Through the interaction of the fungus, acid and pulverized cathode, we can extract the valuable cobalt and lithium. We are aiming to recover nearly all of the original material."



The fungi Aspergillus niger (top left), Penicillium simplicissimum (top right) and Penicillium chrysogenum (bottom) can recycle cobalt and lithium from rechargeable batteries.
Credit: Aldo Lobos

Results so far show that using oxalic acid and citric acid, two of the organic acids generated by the fungi, up to 85 percent of the lithium and up to 48 percent of the cobalt from the cathodes of spent batteries were extracted. Gluconic acid, however, was not effective for extracting either metal.

The cobalt and lithium remain in a liquid acidic medium after fungal exposure, Cunningham notes. Now his focus is on how to get the two elements out of that liquid.

"We have ideas about how to remove cobalt and lithium from the acid, but at this point, they remain ideas," he says. "However, figuring out the initial extraction with fungi was a big step forward."

Other researchers are also using fungi to extract metals from electronic scrap, but Cunningham believes his team is the only one studying fungal bioleaching for spent rechargeable batteries.
Cunningham, Harwood and graduate student Aldo Lobos are now exploring different fungal strains, the acids they produce and the acids' efficiencies at extracting metals in different environments.

American Chemical Society. "Fungi recycle rechargeable lithium-ion batteries." ScienceDaily. ScienceDaily, 21 August 2016. <www.sciencedaily.com/releases/2016/08/160821093037.htm>.

Innovation Metals Corp. Announces Successful Pilot-Scale Separation of Nickel and Cobalt from Laterite Ores Using Proprietary Low-Cost RapidSX™ Process

TORONTO, August 5, 2016 – Innovation Metals Corp. ("IMC" or "the Company") is pleased to report on the successful separation of nickel and cobalt from nickel-laterite ores at the pilot scale, using its proprietary RapidSX™ process for the low-cost separation of technology metals.

The patent-pending RapidSX process has previously been used to successfully separate rare-earth elements ("REEs") from concentrates (as recently announced in IMC's news release dated February 18, 2016). The process was more recently applied to the separation of nickel, cobalt and other valuable metals, from a pregnant leach solution ("PLS") produced from a bulk sample provided by a major miner of nickel-laterite ores. Commercial-grade (99.6%+) purities were obtained.

"In addition to utilizing IMC's RapidSX process for the separation and purification of these valuable metals once in solution," said Patrick Wong, CEO of IMC, "we have combined a unique, proprietary chloride-based leaching process for producing the PLS, with a cost-saving acid-regeneration step. This allows us to extract and to monetize over 80% of the metals present in these ores (compared to the typical 2-3% seen with current laterite-ore processes), while reducing acid consumption and cost. We are now looking for Strategic and Financial Partners who can see the benefit of such an approach to lateritic-ore processing."

Nickel is of vital importance in the manufacturing of stainless steel, other steel, non-ferrous and super alloys, as well as plating, metal-hydride rechargeable batteries and catalysts. Cobalt is essential for the production of Li-ion rechargeable batteries, super alloys, cutting tools, high-performance magnets, catalysts and other applications. Almost all cobalt, however, is produced as a by-product of copper and nickel mining, and sustainable sources can only be achieved through low-cost extraction methods.

"Existing nickel-sulfide deposits are being depleted through mining," commented Gareth Hatch, President of IMC, "with few high-quality exploration targets on the horizon. Nickel-laterite deposits are therefore set to become the most important source of nickel in the future. In addition, future demand for cobalt in Li-ion batteries is projected to grow dramatically, as electric vehicles take increasing market share in the automotive sector. This combination of factors, makes it vital that the industry has access to efficient processes for producing nickel and cobalt from lateritic ores, that are cost effective even at today's relatively low prices for these metals. We believe that IMC's approach is one such process."

The RapidSX approach reduces the number of solvent-extraction ("SX") stages required for nickel and cobalt separation, by over 50% when compared to conventional SX, leading to a significant reduction in plant footprint and associated capital expenditures. The process also leads to dramatic reductions in operating costs and time to process completion, avoiding the need for expensive resins or other separation approaches unproven at scale. It was originally developed as a result of IMC's participation in a recent process-development program, funded by the US Army Research Laboratory, part of the US Department of Defense.

IMC's overall process approach for nickel and cobalt includes the electrowinning of the metals produced via the RapidSX process. The multi-stage approach also produces a number of other, valuable commercial-grade metallic compounds, of significant interest to the specialty-chemicals industry.

"We are pleased to add the successful production of commercial-grade nickel and cobalt, to the previous milestone of separating REEs using the RapidSX process," said Mr. Wong. "We are in advanced discussions with a number of potential lateritic-ore feedstock suppliers and customers, and we are particularly keen to partner with existing industry players, who would benefit significantly from the overall IMC approach. The next step is to complete our pilot-scale program, ahead of building a demonstration plant for the production of nickel, cobalt and other valuable products, from lateritic ores. This plant will produce over 1,000 tonnes of nickel and 150 tonnes of cobalt per year."

About Innovation Metals Corp.

Innovation Metals Corp. ("IMC") is a private Canadian-based company and the developer of the RapidSX™ process, a patent-pending, low-cost approach to the separation of nickel, cobalt, REEs and other technology metals, via solvent extraction. The company will provide low-cost separation capabilities to current and existing producers, assuring security of supply for end users and sovereign governments.

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High-purity metals from battery waste

Researchers have succeeded in recovering important metals – lithium, cobalt and nickel – from battery waste with nearly 100 per cent purity. Recovered metals will be needed increasingly in the manufacture of batteries, and in the future especially in batteries of electric vehicles.

Researchers have been able to extract cobalt at 99.6 per cent purity, nickel at 99.7 per cent purity, and lithium at 99.9 per cent purity from battery waste. According to Post-doctoral Researcher **Sami Virolainen**, who conducted the study, the purity of metals used as raw material in battery manufacturing is particularly important.

"The manufacturing of new batteries requires metals of particularly high purity. If the purity of lithium is below 99.5 per cent, it is not suitable as raw material for batteries. In other words, the difference between 99.4 per cent and 99.9 per cent purity is very significant."

Lithium and cobalt are increasing in importance because they are needed in batteries of electronic devices and especially in electric cars. Forecasts indicate that the global need for lithium may quadruple between the years 2011 and 2025. Europe has few primary lithium resources, which means extraction and recovery from secondary raw materials are important ways to secure its availability.

"Lithium has not been labelled by the EU as a critical raw material, and it is not particularly expensive. However, changes in demand make it a raw material of considerable societal interest," reflects Virolainen.

Used batteries compose a potential raw material source for lithium recovery constantly increasing in quantity. Moreover, the operating life of batteries is only roughly a decade. In other words, batteries keep accumulating, but so does recyclable metal from battery waste. The study separated metals through a liquid-liquid extraction process on a pilot scale. In the process, extraction takes place between two liquid phases which do not dissolve in each other. First, all other impurities are separated from the solution, leaving only lithium, cobalt and nickel. Previous studies have attempted to extract all three metals, but have only succeeded in extracting two at a relatively high purity and the third with low purity.

"As a separation process, liquid-liquid extraction is a viable option when nearly 100 per cent purity and a high recovery rate are required."

Of the three metals, nickel is used in lower quantities for manufacturing batteries, and its availability is not at risk. However, in nature it is always associated with cobalt, and the two are difficult to separate. For use in batteries, cobalt must be separated from nickel. A high nickel recovery rate can be seen in the purity of the two other elements.

The research was conducted with a device with high flow rates simulating the industrial scale. The results of the research were presented in the Circular Materials conference organised by Chalmers University of Technology in early May.

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First posted on www.lut.fi on 01/06/2016 (http://www.lut.fi/web/en/news/-/asset_publisher/lGh4SAywhcPu/content/high-purity-metals-from-battery-waste)

Researchers Develop Safer, Lighter Lithium-ion Battery

Researchers from several universities have developed a battery chemistry for a conventional, fully sealed lithium-ion battery, promising similar theoretical performance as lithium-air batteries, while overcoming all of the known drawbacks of lithium-air units.

The serious drawbacks of lithium-air batteries include wasting much of the injected energy as heat and degrading relatively quickly. They also require extra components for oxygen gas pumping, in an open-cell configuration that is very different from conventional sealed batteries.

Ju Li, the Battelle Energy Alliance Professor of Nuclear Science and Engineering at MIT, explained the shortcomings of lithium-air batteries as the mismatch between the voltages involved in charging and discharging the batteries. The batteries' output voltage is more than 1.2 volts lower than the voltage used to charge them, which represents a significant power loss incurred in each charging cycle. "You waste 30% of the electrical energy as heat in charging. It can actually burn if you charge it too fast," said Li.

In a conventional lithium-air battery, oxygen from the outside air drives a chemical reaction with the battery's lithium during the discharging cycle, and this oxygen is then released again to the atmosphere during the reverse reaction in the charging cycle.

In the new nano-lithia cathode battery variant, the same kind of electrochemical reactions take place between lithium and oxygen during charging and discharging, but they take place without ever letting the oxygen revert to a gaseous form.

Instead, the oxygen stays inside the solid and transforms directly among its three redox states, while bound in the form of three different solid chemical compounds—Li_2O, Li_2O_2 and LiO_2—which are mixed together in the form of a glass.

This reduces the voltage loss by a factor of five, from 1.2 volts to 0.24 volts, so only 8% of the electrical energy is turned to heat, according to Li: "This means faster charging for cars, as heat removal from the battery pack is less of a safety concern, as well as energy efficiency benefits."

The secret to the new formulation is creating nanometer particles called nano-lithia, which contain both the lithium and the oxygen in the form of a glass, confined tightly within a matrix of cobalt oxide. Transitions among LiO_2, Li_2O_2 and Li_2O can take place entirely inside the solid material, according to Li.

The nano-lithia particles would normally be very unstable, so the researchers embedded them within the cobalt oxide matrix, a sponge-like material with pores just a few nanometers across. The matrix stabilizes the particles and also acts as a catalyst for their transformations.

The new battery never needs to draw in any outside air.

The new battery is also inherently protected from overcharging because the chemical reaction in this case is naturally self-limiting—when overcharged, the reaction shifts to a different form that prevents further activity. "We have overcharged the battery for 15 days, to a hundred times its capacity, with no damage at all," said Li.

In cycling tests, a lab version of the new battery was put through 120 charging-discharging cycles, and showed less than 2% loss of capacity, indicating that such batteries could have a long, useful lifetime. Such batteries could be installed and operated just like conventional, solid, lithium-ion batteries, and could be easily adapted to existing installations or conventional battery pack designs for cars, electronics or even grid-scale power storage, according to Li.

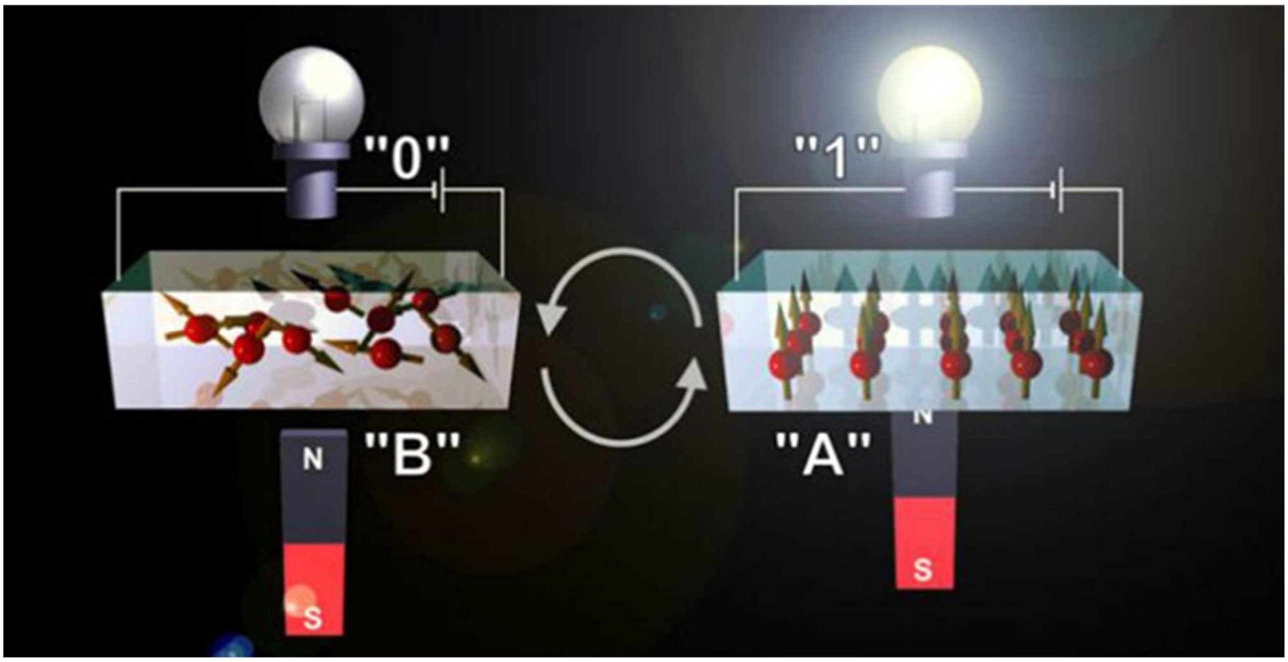
The much lighter "solid oxygen" cathode design could store as much as double the amount of energy for a given cathode weight, and with further refinement of the design, the new batteries could ultimately double that capacity again, according to Li. The carbonate used as the liquid electrolyte "is the cheapest kind," and the cobalt oxide component weighs less than 50% of the nano-lithia component, making the new battery system "very scalable, cheap and much safer" than lithium-air batteries, according to Li.

The team expects to move from this lab-scale proof of concept to a practical prototype within about a year.

The nano-lithia cathode battery is described in the journal Nature Energy in a paper by Ju Li; postdoctoral scholar Zhi Zhu; and five others at MIT, Argonne National Laboratory and Peking University in China. The work was supported by the National Science Foundation and the U.S. Department of Energy.

Posted by Nicolas Mokhoff on 06 August 2016
http://electronics360.globalspec.com/article/7115/researchers-develop-safer-lighter-lithium-ion-battery

New Device Could Double USB Storage Capacity



Using two forms of strontium cobalt oxide with different oxygen content, the device can be switched from an insulating/non-magnet state to a metallic/magnet state simultaneously by electrochemical oxidation/reduction reaction at room temperature in air. (Image Credit: Hiromichi OHTA, Hokkaido University)

Japanese scientists at Hokkaido University have developed a device that uses both magnetic and electronic signals, which could nearly double the storage capacity of traditional memory devices like USB flash drives.

USB flash drives are electronic data storage devices that store information by using millions of small gates that process information into "words" consisting of various combinations of the numbers 0 and 1.

The researchers discovered the ability to use magnetic signal along with the electronic signal to create two times the storage capacity in these "multiplex writing/reading" devices. In addition to the binary 0/1 method of storing information, this creates an A/B store for the information as well. This would require finding a material that can switch back and forth from a magnet to a non-magnet state.

The device can be switched between the two via two forms of strontium cobalt oxide with different oxygen contents. The device can be switched from an insulating/non-magnet state to a metallic/magnet state simultaneously by electrochemical oxidation/reduction reaction at room temperature in air.

The team worked with two forms of strontium cobalt oxide (SrCoOx) to create the device– an insulating non-magnet and a metal magnet. By changing the oxygen content in this compound, the team caused it to switch between the two forms. Currently there are two methods available, but one requires using a high temperature heat treatment and the other method involves a dangerous alkaline solution. This would require that a device is sealed so that the solution does not leak. These methods have proven to be challenging.

The new method uses strontium cobalt oxide safely at room temperature in air. The team applied a sodium tantalate thin film, which can be used at room temperature without leaking alkaline solution, over layers of strontium cobalt oxide. When they applied a three-volt current – about one-seventh of the voltage required in currently available USB flash drives – the insulating form of the solution switched to its metal magnet form, $SrCoO_3$, in three seconds. Current devices can store information in 0.01 seconds.

According to the researchers, making the device smaller would shorten the time needed for the compound to switch between an insulator and magnet. This would allow the storage of an even larger number of photos and videos in mobile phones.

Posted on http://electronics360.globalspec.com/ by Nicolette Emmino on 11 July 2016 (http://electronics360.globalspec.com/article/6980/new-device-could-double-usb-storage-capacity)