

Rare-earth Information Center **INSIGHT**

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Critical Separation

Scientists at the University of Arizona, Tucson, and Los Alamos National Laboratory, Los Alamos, New Mexico, have developed a process which may be useful in separating the rare earth elements from other elements in their ores, and possibly for separating the tetravalent lanthanides (Ce, Pr and Tb) from the divalent and trivalent ones. The original work upon which these ideas developed were published and patented about 18 months ago [N. Yanagihara *et al.*, **J. Less-Common Metals** 167, 223 (1991), and Q. Fernando *et al.* **U.S. Patent 5,045,289** (Sept. 3, 1991)]. These scientists found that by reacting an aqueous suspension of the rare earth oxide, R_2O_3 , with CO_2 under supercritical conditions, the normal trivalent carbonates, $R_2(CO_3)_3$, are readily formed within an hour. In the case of Nd_2O_3 , the highest yields (~95%) were obtained at 40°C and pressures greater than 100 atmospheres. The lanthanide oxides, CeO_2 , Pr_6O_{11} , Tb_4O_7 , Er_2O_3 and Yb_2O_3 , and ZrO_2 did not form carbonates under these conditions, and the authors suggested that these elements might be separated from the R_2O_3 lanthanide oxides, where $R = La, Nd, Sm, Eu, Gd, Dy$ and Ho . This raises several questions which are unanswered, at least as far as we are aware. What happens if one starts out with a mixture of R_2O_3 in which the Ce, Pr and Tb ions are in the trivalent state, as they might be in some of their ores? Are these ions oxidized to form the respective higher valent, normal oxides noted above and thus most likely will not form the carbonates? Or will they remain in the trivalent state and thus form the carbonates, and remain unseparated in the $R_2(CO_3)_3$ mixture? The claims of the patent would suggest that the former occurs, but no data were presented to substantiate this claim. The second question is: how does Y_2O_3 behave? Again the patent claims that yttrium can be separated from the normal trivalent R_2O_3 and end-up with the CeO_2 , ZrO_2 and ThO_2 fraction, but no data were given to support this claim. The third, and probably the most interesting question is: why Er_2O_3 and Yb_2O_3 do not form carbonates, while Ho_2O_3 does so readily? This is especially intriguing since Ho and Er are neighboring lanthanide elements and would not expect such an abrupt change on going from one trivalent lanthanide to the very next trivalent lanthanide. Could it be that the Er_2O_3 and Yb_2O_3 were sufficiently hard-fired that the oxides would not react with the CO_2 to form the carbonate in a reasonable time period?

The patent covers the processing of the rare earths after the ore (primarily monazite, but bastnasite was also mentioned) had been broken down, and the rare earth and related elements had been dissolved and then converted to the oxide or hydroxide. The carbonates are prepared by adding the oxide powder (or the hydroxide) to distilled water and placing this suspension in an autoclave, which was then cooled to an acetone-dry ice mixture temperature to freeze the water suspension. Liquid CO_2 was added, and after the temperature was raised to 40°C, the pressure was increased to 100 atmospheres. After one hour the solution in the autoclave was

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filtered and the solid treated with 0.5M HCl solution to dissolve the carbonate phase, while the unreacted oxides remained as the solid residue, thus readily separating the R_2O_3 carbonate formers from the higher than 3+ valent oxides, such as CeO_2 , PrO_{11} , Tb_4O_7 , ZrO_2 and ThO_2 .

The authors believe their process is economically viable and highly efficient relative to conventional processing techniques such as leaching. The patent is held by Research Corporation Technologies, Tucson, Arizona, and they are seeking partners to develop the process in exchange for intellectual property rights.

At this stage the process seems to hold some promise and is sufficiently worthwhile to carry out further studies to answer a variety of questions and concerns, some of which have been expressed above. If these are sufficiently well addressed and correctly answered, pilot plant studies will need to be carried out to verify the authors' claims of having developed a viable, economic process for separating the rare earth (lanthanide) elements from the other elements in their ores.

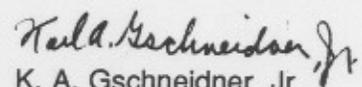
Optical Computer

In mid-January 1993 a University of Colorado research team announced they had built the first truly general purpose optical computer - a machine which stores its programs and processes information entirely by photons, rather than electrons. The Colorado optical computer differs from earlier optical devices in its ability to store and manipulate its own instructions internally -- the earlier optical "computers" required instructions and data to be fed to it by an electronic computer. Although the optical computer with its array of lasers, switches and optical fibers is at an equivalent stage as the vacuum tube electronic computer of the early 1950's, it has the power of a present day personal computer. Future optical computers will be able to function thousands of times faster than conventional electronic computers.

This is good news for the rare earth industry because of the use of high purity rare earths in lasers, optical fibers and optical switches. Unfortunately, the big impact on the industry is at least ten years away, when optical computers will become a commercial product and not a research and development machine. One of the major drawbacks is the cost of the lithium niobate switches, which cost \$3000 each. A current design on the boards uses 66 of them, which amounts to about *one-fifth of a million dollars* for the optical switches alone.

Goldschmidt → Elektro-Thermit

As of January 1, 1993 the metallurgical activities, including the rare earth magnet alloy products of Th. Goldschmidt AG was merged with Elektro-Thermit GmbH. Elektro-Thermit is a wholly owned subsidiary of Goldschmidt.


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