Letters

A Sound Use for Metal Foams

In the article on metal foams by John Banhart and Denis Weaire (PHYSICS TODAY, July 2002, page 37), I saw no discussion of possible acoustical absorption applications. Controlled interconnection of pores is, of course, necessary for broadband sound absorption. Possibly that property, combined with certain of its structural abilities, would make metal foam a unique high-performance structural material.

When doing architectural acoustics consulting in New York and Chicago, Tony Paolello of the New York City Transit Authority and George Krambles of the Chicago Transit Authority both expressed the hope that an economical, easily cleaned, sound-absorbing, and extremely durable material would be found for lining subway tunnels. Could metal foams be such a material? Combined with damped sheet steel backup for sound isolation, these materials would seem ideal for the subway system's sound-absorbing surfaces. Since metal foams can be rigid enough to bear the weight of workmen, transit systems might also be able to use them to make noise barriers that can pivot from the vertical to the horizontal to become maintenance walkways.

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Banhart replies: Aluminum foams are, almost by definition, materials with closed cells that have no interconnections; therefore, the foams are poor sound absorbers. However, as liquid metal foams solidify, thermal stresses occur: The solidified foams usually have cracked cell walls, which significantly increase sound absorption. In addition, by slightly rolling thin sheets of foam from, say, a thickness of 10 mm to 9 mm, further mechanical cracking occurs, and the interconnections between adjacent cells widen. Thus, sound absorption increases even more. The result is an absorber that has its maximum between 1 and 5 kHz with a peak absorption coefficient of up to 95%. By placing an air gap between foam and a rigid wall, one can shift the frequency curve to lower frequencies.

Altogether, metal foam is not a very good sound absorber; other materials—glass wool, for example—show an almost constant 99.9% absorption over a wide frequency range. However, other metal foam properties—namely, high weight-specific stiffness, good crash-energy absorption ability, and nonflammability—might make them marketable for sound absorption panels. Reportedly, the Japanese railways are using aluminium foam panels to damp the shock waves caused by trains as they enter tunnels, so the application suggested by David Klepper is worth evaluating.

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Letters and opinions are encouraged and should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842 or by e-mail to ptletter@aip.org (using your surname as "Subject"). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit submissions.

More on Carbon Sinks

Jorge Sarmiento and Nicolas Gruber (PHYSICS TODAY, August 2002, page 30) mention that carbon dioxide has a relatively long residence time in the atmosphere because it is nonreactive there. However, that statement could be misleading. The residence time of a gas at equilibrium in a reservoir is $\tau = M/F$, where M is the total mass of the gas in the reservoir, and F is either the rate of release plus formation or the rate of removal plus decomposition.[1] Thus, the residence time of CO_2 should not be considered as an indication of its atmospheric nonreactivity.

Since the authors neglect atmospheric reactions of CO_2, the article ascribes all sinks of atmospheric CO_2 to either terrestrial or oceanic sources. We suggest that the models should also include atmospheric reactions.

Atmospheric CO_2 and included carbonate aerosols form carbonic acid in cloud droplets in the atmosphere. The carbonic acid undergoes dissociation to bicarbonate and carbonate ions sufficiently rapidly to influence rainwater pH. That natural mechanism removes atmospheric CO_2 from the atmosphere. The magnitude of that gaseous scavenging process is not characterized well enough for a quantitative estimate of the magnitude of the sink, but large volumes of air flow through clouds and are processed by precipitating clouds during their life cycle. Land and water sinks for atmospheric CO_2 provide surfaces that interact only with the air in the immediate proximity.

Although atmospheric CO_2 has been regarded by many as chemically nonreactive, formate ions and formaldehyde are produced by its reduction in single ice crystals in mixed clouds—those having regions that contain both liquid and solid phases—when the cloud droplets contain low concentrations of sodium chloride.[2] It is assumed, but not determined, that methyl alcohol is also a product of the reduction process. A number of laboratory cloud chamber and field experiments have demonstrated that growing ice crystals containing low concentrations of calcium carbonate or magnesium carbonate derived from terrestrial dust also absorb and reduce CO_2. This class of chemical reactions occurs at growing ice interfaces in the presence of appropriate solutes in the system. The presence of formate ions in natural precipitation, which is normally attributed to the oxidation of methane by hydroxyl free radicals, may actually be the result of reduction of CO_2.

In their figure 3, Sarmiento and Gruber show a strong correlation of incidences of El Niño years with higher CO_2 accumulation rates in the atmosphere. The authors suggest that the correlation may be the result of terrestrial vegetation's response to climatic variability. The presence of the growing ice phase in the atmosphere is highly variable and may contribute to the observed correlation shown. During El Niño years, there is a significant reduction in oceanic precipitation over a significant portion of the globe's tropical oceans, thus reducing both the incidence of maritime clouds and the opportunity for CO_2-reducing reactions in the growing ice phase of those clouds.

Sarmiento and Gruber mention the uncertainty associated with CO_2 uptake in the Southern Ocean. At

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60° S, oceans exist at all longitudes; the climatic high frequency of storms at that latitude is reflected in the rising air in the Ferrell Cell (the region near 60 S) of the general circulation. Consequently, this region contains both maritime clouds and storms, in which cloud glaciation occurs and frequently leads to precipitation. Thus, the uncertainty of results that Sarmiento and Gruber find in the region near 60° S is probably partially due to weather patterns leading to chemical reduction and removal of carbon dioxide in precipitation.

Before reading the article, we believed that the atmospheric reactions to remove CO_2 could not compare in magnitude to the estimated oceanic and terrestrial sinks. Inclusion of atmospheric reactions that chemically reduce CO_2 in mixed clouds, followed by removal of the resulting products in precipitation, might advance the modeling technique presented in Sarmiento and Gruber's article.

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2. W. G. Finnegan, R. L. Pitter, B. A. Hinsvark, *J. Colloid Interface Sci.* **242**, 373 (2001).

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In their article, Jorge Sarmiento and Nicolas Gruber emphasize a premise that carbon dioxide is the most prominent greenhouse gas causing global warming. In contrast, NASA, in a newspaper article two months earlier (*New York Times*, 31 May 2002, p. A16), stated that water vapor is the "dominant natural heat-trapping gas." Telemetry that NASA installed recently on the satellite Aqua is intended for making a worldwide study of water vapor.[1] We already know from previous satellite measurements summarized by B. J. Mason[2] that, on average, more than 50% of Earth's surface is covered by clouds.

Both CO_2 and water vapor are considered from a historical perspective by Spencer R. Weart in PHYSICS TODAY, January 1997, page 34. Experimental spectroscopic studies of infrared absorption in laboratory air cells are cited; the most recent of those studies go back to 1911. John Tyndall made spectroscopic studies in 1861 on air mixtures and concluded that water vapor was a factor of 10 stronger than CO_2 in its IR absorption.

Our purpose here is to encourage revisiting and modernizing those early experiments using modern spectrographic methods to investigate a range of gas mixtures, radiation wavelengths, pressures, and temperatures. This activity would provide IR absorption coefficients having a higher confidence level. Such scientific data will help investigators and funding agencies evaluate where money is best spent to understand global warming.

References

1. For more information on the Aqua mission, see http://aqua.nasa.gov.
2. B. J. Mason, *Contemp. Phys.* **43**, 1 (2002).

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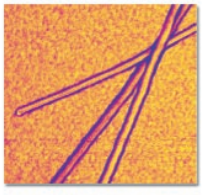

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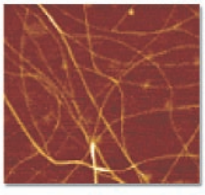

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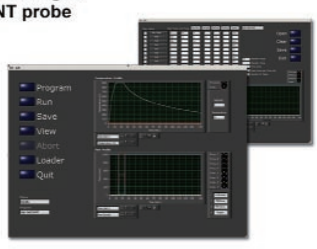

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