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Silica Aerogel for Protecting Stored Seed or Milled Cereal Products from Insects

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In recent years much has been published regarding the effectiveness of silica dusts mixed with grain and seed to protect them from insect attack. These dusts cause the death of insects by abrading the waxy coating of their cuticle, thus destroying its impermeability and promoting the rapid loss of body moisture. Insects that live in stored grain and similar dry food materials depend upon their food supply for their moisture needs. When feeding in grains or milled cereals that contain only the normal percentage of moisture, insects cannot readily replace water lost as a result of abrasion by dusts, and death by desiccation quickly follows. **Experiments conducted by the writers with a finely divided silica, known as silica aerogel, indicate this material to be more effective against the insect pests of stored grain and milled cereal products than any other form of silica tested.**

The original source of the silica is sodium silicate. In the manufacture of the aerogel the liquid phase of the gel form is removed without otherwise altering the structure. Air replaces the liquid which was present when the gel was made. This process results in a dry, light particle having the same volume as the original gel. Unlike ordinary silica gel, the aerogel is not hygroscopic.

The typical chemical analysis of this material is as follows: SiO, 89.5 to 91.5 per cent; volatile (water, alcohol, and acetaldehyde), 5 to 6 per cent; sodium sulfate, 2.5 to 3.5 per cent; aluminum oxide plus ferric oxide, 1 per cent; pH (2.5 grams suspended in 100 cc. of water), 3.5 to 4 per cent.

The physical properties are as follows: color, white; dry bulk density, approximately 6 pounds per cubic foot; absolute density, 127.9 pounds per cubic foot; specific gravity, 2.2; oil absorption, too high for conventional test methods; index of refraction, 1.464; average particle diameter, 3 to 5 microns.

The effectiveness of silica aerogel in protecting seed wheat and various types of milled-cereal products was

tested by confining adults of the confused flour beetle *Tribolium confusum* Duv., the rice weevil *Sitophilus oryza* (L.), or the granary weevil *S. granarius* (L.), and larvae of the confused flour beetle and the Mediterranean flour moth *Ephestia kühniella* Zell., in samples of wheat ranging from 50 to 500 grams treated with various dosages of the dust. Results obtained in this series of tests indicate that the minimum effective dosages for various materials are as follows:

Material	*Silica Aerogel, Per Cent by Weight*
Seed wheat of 12 per cent moisture content	0.025
Seed wheat of 14 per cent moisture content	0.05
Feed in pellet form	0.025
Feed, Ground	0.5
Bird food (mixture of seeds and finely ground feed)	1.0
Powdered hand soap (60 per cent cornmeal)	0.05

One treatment with silica aerogel should afford protection to feed or seed from insect damage for an indefinite period. It was observed that heavy treatments caused 100 per cent mortality of insects in 1 to 2 weeks, whereas marginal dosages required 5 or 6 weeks to give a complete kill of insects introduced into the treated samples.

Preliminary tests indicate that light applications of silica aerogel to the surface of wheat in farm storage bins may be useful in preventing infestation by incoming insects. Its use throughout the bulk of grain to protect it against weevil damage is not recommended, since grain so treated would be classified under the official standards of the United States as treated, and graded "limed," and hence subject to discount. Although cleaning operations will remove much of the excess dust, enough will cling to the bran coat of wheat kernels to make its presence evident to the touch.

To test its oral toxicity, the manufacturers of silica aerogel report that in the course of feeding experiments

a suspension of silica aerogel in water (100 grams per liter, total volume) was prepared and administered to guinea pigs. Each guinea pig received 2 milliliters of the suspension or 200 milligrams of dust, 6 days a week for 2 months. The conclusions of the pathologist making the tests were as follows:

"The daily ingestion by guinea pigs of 200 milligrams of the material fails to affect the growth and does not produce the pathological lesions which would be expected if the material were absorbed."

No experiments have been conducted to determine its effect on the palatability of treated grains and mill feeds.

The dust is highly irritating when breathed. Therefore, if products are treated with silica aerogel, workmen should be protected from breathing the dust by the use of suitable respirators and by proper ventilation.

With reference to the possible silicosis hazard from breathing the dust, the manufacturers have issued the following statement:

"Unpublished work at a reliable institution showed no evidence of acute toxicity after inhalation of the powder in concentrations as high as 60 milligrams per cubic foot of air. This concentration is much higher than found in any industrial application. The interpretation of these figures is that silica aerogel possesses negligible acute toxicity.

"Clinical and x-ray studies in workers exposed to silica aerogel during manufacture for the past five years as well as preliminary animal experimentation show no evidence of a silicosis producing property. Silica aerogels as a rule are not capable of producing nodular fibrosis of a silicotic type.

"However it is recommended that dusting be kept to a minimum by proper ventilation and that workers exposed to continuous dust wear satisfactory respirators."