New source identified for Mexico City smog

Smog hangs over rooftops in Mexico City.

Andrew Davis/Greenpeace

In Mexico City, almost every day is a bad air day. The concentration of harmful ozone gas rises so frequently into the unhealthful zone that 98 percent of the days in 1992 exceeded safety levels.

In trying to combat smog ozone, which gets trapped over the city by surrounding mountains, Mexican authorities have focused on cars and industry as the prime culprits. But a pair of atmospheric chemists now identifies another major, yet far less obvious, cause of the city's air pollution.

Leaking canisters of liquefied petroleum gas (LPG) account for one-third to one-half of the ozone in the city's smog, contend Donald R. Blake and F. Sherwood Rowland of the University of California, Irvine. The 20 million residents of Mexico City use LPG as fuel for heating water and for cooking.

"Progress in [fighting pollution] is really going to depend on thinking of all the sources, and here is a major source that their control procedures have not considered in the past," says Rowland.

Blake and Rowland discovered the link between smog and LPG after studying 180 air samples collected at widely separated sites in Mexico City. When the scientists analyzed the different types of hydrocarbons within the air samples, they discovered high concentrations of propane and two species of butanes. These amounts could not have come from car or industrial exhaust, they report in the Aug. 18 SCIENCE.

Propane in the Mexico City samples often exceeded 100 parts per billion and on one occasion reached 600 parts per billion. In contrast, a previous study of 39 U.S. cities showed median propane concentrations of 8 parts per billion, with a maximum of 131.

Because the propane, butanes, and other hydrocarbons in the air matched the composition of LPG, Blake and Rowland concluded that the hydrocarbons came from leaking canisters. The concentrations of such gases were consistent throughout the city, ruling out the possibility of just a few large sources. Instead, Blake and Rowland believe, upward of a million canisters in individual homes could be leaking.

The LPG hydrocarbons—particularly the butanes and a related chemical called butene—create problems because they are reactive molecules that help form ozone, the principal component of smog. When cooked by sunlight, the hydrocarbons react with oxides of nitrogen, or NO_x, to generate molecules of ozone, which can cause respiratory problems in humans and damage to vegetation.

In Mexico City, as in Los Angeles and elsewhere, NO_x comes from fossil fuel combustion, chiefly car exhaust and industrial emissions. In many cities, cars and industry also emit the hydrocarbons necessary for ozone formation.

Officials in Mexico City have attempted to reduce automobile emissions by prohibiting residents from driving one day a week. Furthermore, all cars in Mexico built after 1992 have catalytic converters, which cut down on NO_x emissions. Indeed, ozone concentrations have dropped since 1992.

But Blake and Rowland contend that authorities must tackle LPG leakage if they want to reduce ozone further. As one solution, the chemists suggest changing the fuel's composition slightly, to a formula more like that of the LPG sold in the United States. This would eliminate the most potent ozone producers—the butanes and butene. Reducing the amount of LPG leaked could also stem the flow of hydrocarbons into the atmosphere.

Francisco Guzman, a chemical physicist at the Mexican Petroleum Institute in Mexico City, says that Mexican researchers in the past have recognized LPG as a source of hydrocarbon pollution. But they judge LPG's role in ozone formation to be less important than Blake and Rowland suggest. "In our opinion, it is not that much. Certainly it is not as high as 50 percent," says Guzman. To resolve the discrepancy, Guzman is leading a research group looking into the role of LPG in Mexico City.

Blake and Rowland have found hints that the LPG problem also afflicts other cities, such as Taipei, Taiwan, Athens, and some cities in Eastern Europe.

— R. Monastersky

Speeding into coordinated movement

Whether it's a precision marching band striding through a complex routine or a school of fish executing a sharp turn, coordinated motion is an impressive sight. Even bacteria in large, growing colonies can exhibit cooperative movement to survive under unfavorable conditions.

Now, a group of physicists has developed a simple computer model that illustrates how rudimentary rules of behavior applied to self-propelled particles moving independently can lead to synchronized activity.

Tamás Vicsek of Eötvös University in Budapest and his coworkers describe their model in the Aug. 7 PHYSICAL REVIEW LETTERS.

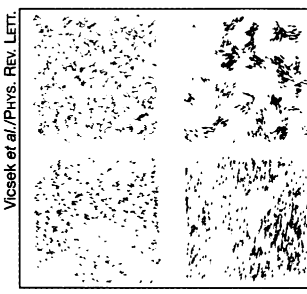
In their model, a given area is sprinkled with a certain number of particles. Each particle moves at the same speed, but in a random direction.

Starting with this configuration, the computer calculates particle velocities at subsequent times according to a simple rule: With each time step, every particle assumes the average direction of motion of the particles in its immediate neighborhood, modified by a small, random perturbation.

Computer simulations reveal that the type of movement observed depends on the number of particles packed into a given area and on the level of random perturbation, or noise (see illustrations). Remarkably, at high densities and low noise, all of the particles end up moving in the same spontaneously selected direction.

"The proposed model is interesting because of possible applications in a wide range of biological systems involving clustering and migration," the researchers say. For example, with some modifications, it is capable of reproducing the collective rotation and flocking of bacteria (SN: 3/4/95, p.136).

— I. Peterson



Vicsek et al./PHYS. REV. LETT.

Small arrows indicate the initial velocities of a random distribution of particles (top left). For small densities and low noise, the particles tend to form clumps moving coherently in random directions (top right). At higher densities and noise, the particles move nearly randomly, with just a trace of orderliness (bottom left). For high densities and low noise, the motion becomes ordered (bottom right).