The Pioneers



Arie Jan Haagen-Smit

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Arie Jan Haagen-Smit truly deserves the recognition he long enjoyed as a pioneer in air pollution. He blazed new trails in both the scientific and the public policy aspects of air pollution in a memorable multidimensional career. Equally remarkable is the fact that his involvement in air pollution began when he was 50 (an age when some scientists tend to rest on their laurels) and followed a successful career in the study of the chemistry of natural products. How this "analyzer of pineapple volatiles," already known as a foremost analytical-organic chemist, came to discover a new kind of air pollution triggered by southern California's sunlight—and then led the battle to control it that made him well known in the highest levels of government and industry—is a fascinating story.

The Scientist

In his writings and conversations with his friends and colleagues through the years, Haagen-Smit left indications of the various clues which were responsible, in the late 1940s and early '50s, for leading him to his new career. It was then, for the first time, he recognized that the action of sunlight on organic compounds and oxides of nitrogen in the air caused a new and toxic form of air pollution, photochemical smog. The California Institute of Technology, where Haagen-Smit was professor of bio-organic chemistry, was a particular victim of this "smog," because of its location in Pasadena, California, just downwind from the rapidly growing Los Angeles area. Eye irritation, plant damage, haze, odor and rubber cracking were all recognized as symptoms of "smog". In the fall of 1949, a research program was just getting underway at the Earhart Plant Research Laboratories at Cal Tech to identify the cause of the distinctive "smog" damage to vegetable crops. It was derived in part from earlier observations by John Middleton

and James Kendrick, plant pathologists at the University of California, Riverside, and Harold Schwalm, farm advisor in Los Angeles County, that damage to certain field crops in Los Angeles County could not be accounted for by the Londontype smog-there was something present in the air that was characteristic of the Los Angeles area. The new project was a cooperative effort between plant scientists from Cal Tech, UC Riverside and the Los Angeles Air Pollution Control District. After his initial experiments, Haagen-Smit joined this group. But it was odor that provided the first clue; smog did not smell like the sulfurous coal smoke which plagued cities in the eastern United States and Europe, including those in Haagen-Smit's native Holland. Instead, the "bleach-like" odor of smog reminded him of odors previously encountered in his research and teaching, especially those prevailing in a natural products laboratory. Haagen-Smit had just completed an analysis of the volatile flavor components of pineapple so he simply used his sampling train with freeze-out traps to collect the contaminants in Pasadena smog. The presence of oxygenated organics in the condensate led him to postulate that the distinctive smog symptoms were due to partially oxidized hydrocarbons from southern California's petroleum-based economy, rather than to sulfur compounds.

To test his idea, Haagen-Smit fumigated some smog-sensitive plants with hydrocarbons partially oxidized by ozone. If there was a moment to be labeled "breakthrough," it was when his test plants developed typical symptoms of smog damage. Why did he choose ozone as an oxidizing agent? Probably because he, as a natural products chemist, was familiar with the use of ozone to cleave terpenes (which are natural olefinic hydrocarbons) for structural determination. No doubt there was an ozone generator available in his laboratory for such purposes. However, though successful in creating the first synthetic smog in the laboratory that gave plant damage symptoms like the real "Los Angeles smog," the experiment was not yet complete because it employed artificial ozone. Now Haagen-Smit remembered reading that organic material could be oxidized by air if initiation by light and nitrogen dioxide were provided. He tried such a system and found it to be successful in producing smog symptoms. Haagen-Smit, as noted earlier, had by then joined forces with the group trying to identify the plant toxicant, and the results were published in a landmark paper, "Investigation on Injury to Plants from Air Pollution in the Los Angeles Area," by A. J. Haagen-Smit, Ellis F. Darley, Milton Zaitlin, Herbert Hull and Wilfred Noble, in the Journal of Plant Physiology in

Another clue to the chemical nature of Los Angeles smog came from a Cal Tech study on the accelerated deterioration of rubber products, especially tires, in southern California. Rubber cracking provided a simple, highly useful test method for ozone and also focused attention on ozone as being more than a laboratory chemical and a key component of the stratosphere. Soon Haagen-Smit was using small rubber strips under stress to test his irradiated hydrocarbon/nitrogen dioxide/oxygen mixtures. Sure enough, accelerated cracking of the rubber strips was observed just as it was in the smoggy Pasadena air. But there was some confusion. In his first report of this research, in December, 1950, Haagen-Smit rejected the idea that ozone was responsible for the rubber cracking. Instead he believed that "peroxidized compounds" were responsible. The initial lack of confidence in the specificity of rubber cracking as a test for ozone, along with an intuitive feeling which others had that such a strong oxidant as ozone could not be formed through atmospheric oxidation of hydrocarbons, led many to challenge the validity of Haagen-Smit's results.

The links between smog chemistry and plant chemistry are present but not obvious in this tale. Ozone has a "bleach-like" odor which would sometimes be present in a terpene laboratory as well as in smog. Terpenes are olefinic hydrocarbons as is the natural rubber used to detect ozone. Synthetic rubber

is comprised of similar unsaturated hydrocarbons; in fact, a wartime rubber plant was a contributor of the readily oxidized organics to the Los Angeles smog. So the chemistry of petroleum hydrocarbons in air is not as far removed from plant chemistry as it might seem.

Haagen-Smit soon recognized that ozone could indeed be formed in atmospheric reactions and continued through the first half of the 1950s to use rubber cracking to study ozone both in Pasadena air and in his reaction flasks. He was a center of controversy, all the while becoming more widely known.

In the middle 1950s, confirmation of his chemistry, in particular the formation of ozone in the hydrocarbon-NO_x-sunlight system, began to occur. Some of it was done using instrumental methods in laboratories supported by the petroleum industry. None of the studies really identified the source of the hydrocarbons, although some were unwilling to look any further than the oil refineries which were such a prominent part of the Los Angeles scene. By 1960, however, it became clear that control of automobile emissions also would be necessary if progress were to be made in reducing Los Angeles smog. The scene was thus set for the beginning of the other role in Haagen-Smit's career in air pollution.

The Administrator

In early 1960 the California Legislature recognized that, to be effective, control of auto emissions needed to be statewide. Accordingly, new legislation established the Motor Vehicle Pollution Control Board (MVPCB) and Professor Haagen-Smit was appointed as a charter member. Hopes that some simple control gadget would be forthcoming that the MVPCB could require for every car were not realized. Yet before the MVPCB was transformed into the California Air Resources Board (ARB) in 1966, new cars were finally, beginning with the 1966 model year, being manufactured to meet emission standards for hydrocarbons and carbon monoxide.

When the MVPCB reemerged as the ARB, the "stubborn Dutchman" became chairman and thus the leader in California's effort to control smog. To many, progress seemed agonizingly slow, but this was largely because the job had been badly underestimated. In the beginning, both control technology and measurement methodology were lacking. Haagen-Smit continued to have a real intuition into how and why chemical reactions occur in the atmosphere, as manifested in his often expressed concern on the role played by oxides of nitrogen in all aspects of photochemical smog-not just ozone formation or inhibition. Thus, in the late 1960's he became the leader in the move to install NO_x exhaust emission control devices on motor vehicles, as well as on stationary sources. Indeed, part of the legacy of Haagen-Smit recently was written in the 1977 Amendments to the Clean Air Act by Congress, whose members expressed specific concern not only about nitrogen dioxide, but also on a wide range of other nitrogenous pollutants.

It was as chairman of the ARB, an appointment made by then Governor Reagan, that Arie Haagen-Smit showed his enormous skills in dealing with issues, people and technology. He understood that technological change could not be divorced from societal concerns and felt that, even though progress in emission control was made in small steps, it was in fact solid progress, and that no instant panacea for air pollution existed. He maintained this philosophy throughout his tenure as the first chairman of the ARB.

As chairman, Haagen-Smit was to a large degree responsible for appointing a Technical Advisory Committee (TAC), and here another of his attributes became apparent. He chose a group of professionals in air pollution with widely differing scientific backgrounds, interests and points of view. Consequently, discussions of the TAC were rarely dull, indeed they

often became superheated as the group of control officials, industrial scientists and academicians tried to hammer out a recommendation to the ARB. Haagen-Smit knew that by throwing this diverse group into the arena, useful science, technology and control strategies would ultimately emerge—although the coşts to him as chairman included the challenge of keeping the TAC together long enough to do so!

Professor Haagen-Smit had been at Cal Tech for 12 years before he began his air pollution studies. He went to Pasadena in 1937 following a year at Harvard and several years at the University of Utrecht, the city where he was born on December 22, 1900. In these early years he had built a reputation in the chemistry of essential oils and other natural products of importance in plant life, work which brought him the decoration as Knight of Orange Nassau in 1947. The acceptance of Haagen-Smit's discoveries in air pollution in the 1950s brought him many additional national and international awards and honors, beginning with the Chambers award of the Air Pollution Control Association in 1958, and including in the 1970's the National Medal of Science and membership in the National Academy of Sciences.

The Man

We have chronicled the story of Haagen-Smit the researcher and the scientific statesman, but no tribute would be complete without comment on Haagen-Smit the man. In public and in private, Arie was a charming, gracious and erudite individual with a sense of humor that many observers felt was especially refreshing to see in a professor holding a position of real authority and responsibility. In addition to such attributes, those who had known Arie through the years also recognized that he could be stubborn and quick to anger; an upset Arie Haagen-Smit was a sight to behold! However, he reserved those occasions for situations in which he felt the underdog—whether it be members of the general public, industry representatives or government officials—was being treated unfairly. He was equally quick to forget his ire and never stored a grudge, despite being in "combat" in dozens of major air pollution battles. Furthermore, while he was deeply committed to achieve his goal of clean air, he maintained a neutral viewpoint with respect to interpretation and translation of the available data into legislation. He did not see villains or heroes—just a tough societal and technical task.

With all the above, two things will always come to mind when we think of Arie. First, although he could be deeply involved in a bitter scientific debate with literally billions of dollars riding on the decision, when the meeting adjourned for the day, he could be found engaged in warm repartee over a drink with both proponents and opponents of the issue of the day, all of whom were treated as his personal friends. Second, although Arie's wrath appeared on occasion, to our certain knowledge he never turned it on those who couldn't fight back. Thus, as chairman of the powerful Air Resources Board, all kinds of individuals testified before him-from the presidents of the world's largest corporations to "Joe Motorist" who was worried about the effect of retrofit devices on his car. Haagen-Smit had no qualms in taking on representatives of the power structure, whether they were representatives of industry, government or academia, but he was unfailingly courteous to the "little guy," never embarrassing or putting him down despite occasions when his points were trivial at best.

In short, Arie Haagen-Smit took on the lions, but was gentle to the lambs. It is indeed gratifying that he lived to see the dedication of the new Haagen-Smit Laboratories of the ARB of California—they stand as a tribute to Haagen-Smit, not only a remarkable scientist but also a great man.