PARTICLE ANALYSIS

Problem particles not only cause air and water pollution; they can wreak havoc with industrial processes and interfere with laboratory results. With a microscope and reference photomicrographs, particle identification can be easy.

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If you can recognize a robin or a banana by sight, you should be able to recognize single particles of coal, cement or gypsum when the microscope magnifies them to an equivalent size. This is the thesis of those who identify small particles by microscopy. No other microanalytical method identifies such small samples of such diverse substances so quickly.

Single particles of almost any substance - animal, vegetable, mineral, industrial byproduct, raw material, corrosion product, flyash - can be identified in a few seconds to a few minutes by a microscopist trained in particle identification. The particle must be at least 2 to 3 microns in diameter and 10 picograms or 10^{-11} gram in weight for identification by light microscopy.

Who needs methods this sensitive? Industrial hygienists, for one; particles ingested into the human lung are nearly all smaller than 5 µm in diameter. Harmful particles like asbestos, quartz, lead and beryllium compounds found in lung tissue are seldom larger than 5 µm and these must be recognized and identified. Many particles in air and water pollution samples are smaller than 5 to 10 µm and must be identified. The particles clogging fine fuel jets or synthetic fiber spinnerets are often this small. Many particles smaller than 10 µm can cause serious troubles if they get into magnetic recorder tape or photographic film emulsions. Many solutions, such as ampouled drugs or bottled beverages, are expected to be optically clear, and very tiny particles can scatter light or form visible residues. Finally, as electronic systems become more and more microminiaturized, the more often small particles will cause failures.

More and more the need for identification of small particles is increasing. This is especially true since chemical identification of a particle usually also identifies the source of that particle. A variety of such problems have been solved in our laboratories. In one tragic case, a clogged jet fuel line on an aircraft engine caused a fatal accident. Examination of the clogged jet showed tiny short lengths of glass fibers from a protective filter placed in the fuel line supplying the jet aircraft. In another case, noisy magnetic tapes were found to be due to fine dust particles; the fine dust particles, in turn, were found to be magnetic tape and coating abraded from the edges of the tape by rough metal wind-up spools. One fine example from the many that might be chosen was the presence of very tiny metal particles in photographic film emulsion, each of which caused precipitation of an easily visible spot of metallic silver.

What is Needed

What steps must be taken to identify these tiny samples? Since nearly all are invisible to the naked eye, they must be made visible by using an appropriate microscope. To be able to identify any of the thousands of particles that may be present requires a good polarizing microscope and a trained microscopist. The equipment required may cost as little as $3,000, although any microscopist skilled in this highly specialized field probably deserves more sophisticated equipment as a fringe benefit. A total cost of perhaps $15,000 is more realistic.

In addition, few laboratories are clean enough to permit work of this kind. The laboratory itself is dirty; the air in the room is dust-laden; fingers carry particles; slides and cover slips are never clean. In short, there are millions of particles in any laboratory just as large and just as visible microscopically as the particle to be identified. It is essential that the sample be examined and identified under conditions such that contamination is avoided. This requires a clean bench if not a clean lab.

Now, what properties can be measured on small particles that will aid identification? First is shape: Is it a very flat sheet of mica, highly fibrous asbestos, a pitted fiber of wood pulp, conchoidally fractured quartz or ground glass, or a perfect sphere of flyash from a pulverized coal boiler? Next, size may be important for some substances like pollen, starches, and fibers. Color is very important, and both transmitted and reflected light may be used. The color should also be associated with degree of transparency. Crossed polars should be used to differentiate between isotropic substances such as glass, pumice, fluorite or sphalerite and birefringent substances such as quartz, talc, nylon, fur fibers and starch. The degree of birefringence often permits recognition of limestone, foraminifera, Orlon, quartz, and so forth. The refractive indices are usually not determined precisely, although a quick estimate of the value relative to the mounting liquid is often useful. For example, look-alike calcite and siderite can be quickly and easily differentiated when mounted in the usual mounting medium, Aroclor, which has a refractive index of 1.66. Particle identification with these techniques is called morphological analysis.

Difficulties begin when the microscopical examination fails to identify the particle. Then, the microscopist must have recourse to electron microscopy, X-ray diffraction, BDX or FTIR.

To be able to identify a given particle, the microscopist must either have seen one before or, at least, a good photomicrograph of it. His aim is to associate such microscopical characteristics as shape, surface, transparency, color, birefringence, and refractive index with the name of that substance. A photomicrographic atlas is an ideal solution to the problem because a microscopist can remember the morphological characteristics of only so many different substances. If he can remember a large number, he is still the only one who can make the analyses. An atlas supplements the microscopist's memory and helps other microscopists learn to identify particles.

Authored by the McCrone staff, the Particle Atlas*, formally in six large volumnes, and now on CD-ROM, covers the identification of more than 1,000 common particles. A detailed description of each substance appears with each photomicrograph. Also included are careful descriptions of the techniques necessary for collecting, manipulating, and characterizing particles as well as analytical tables for the identification of specific particles after a simple preliminary classification. With this atlas, an interested person willing to invest the necessary time could become expert in identifying the common particles found anywhere in the world.

* The Particle Atlas, CD-ROM version is available from:

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IMMUNOHISTOCHEMISTRY / IMMUNOCYTOCHEMISTRY

*The following words are intended to be sung to the tune of the ISUZU *AMIGO* Commercial:*

Immuno, immuno
Oh how we love our immuno
We freeze the tisue, make the sections
And then we do some more

Immuno, immuno
Oh how we love our immuno
We make dilutions, run the sequence
And then we rank and score!

Immuno, immuno. . . . . . .

Submitted (with some fear) by John P. Petrali

Photomicrographs

You can have your first lesson free by referring to the above photomicrographs. The photomicrographs shown there are all in The Particle Atlas. To pass your first lesson, you should have identified those at the left, from top to bottom, as diatoms (diatomaceous) magnified 80 times, molding sand (quartz with resin coating) magnified 100 times, and coal fly ash (from a chain grate stoker) magnified 40 times. At right, again top to bottom, are pencil sharpener dust magnified 100 times, bright Nylon magnified 200 times, and wheat grain dust magnified 200 times.

If you identified one or two, you show real promise; three or four, you've probably taken one of our courses. If you identified five or six correctly, let us hear from you.