Materials scientists use chemistry and physics to study the properties of materials. They use their discoveries to develop new or enhance existing products, to strengthen or combine materials, or to develop new materials for specific uses. Of course, the work of materials scientists who specialize in some aspect of corrosion is of most interest to *MP* readers.

So who are these scientists, and what's it really like to do research? Their results are sometimes reported in the news, but that doesn't always give us a clear picture of what went into getting those results. Indeed, there is a perception among some that the life of a research scientist (particularly in academe) is one of leisurely investigation, punctuated by the occasional fantastic discovery. We checked with researchers around the world—academic and commercial—to get the real picture.

A Day in the Lab

The life of a materials scientist

Rikki Mitman, Staff Writer

Meet the Panel

We spoke with five materials scientists to get the scoop on their daily lives. Four are university professors; one works for a large corrosion services company.

Robert Akid—Founder and director of the Centre for Corrosion Technology at Sheffield Hallam University (Sheffield, U.K.) and head of Sheffield's Structural Materials and Integrity Research Centre, Akid is focused on environment-assisted cracking, scanning electrochemical techniques for the measurement of localized corrosion, and sol gel coatings. His current research projects include functional coatings for Cr replacement, anti-bacterial coatings, microbial fuel cells, conventional and novel measurement techniques to evaluate localized corrosion, and quantification of stress-assisted corrosion for structural integrity modeling.

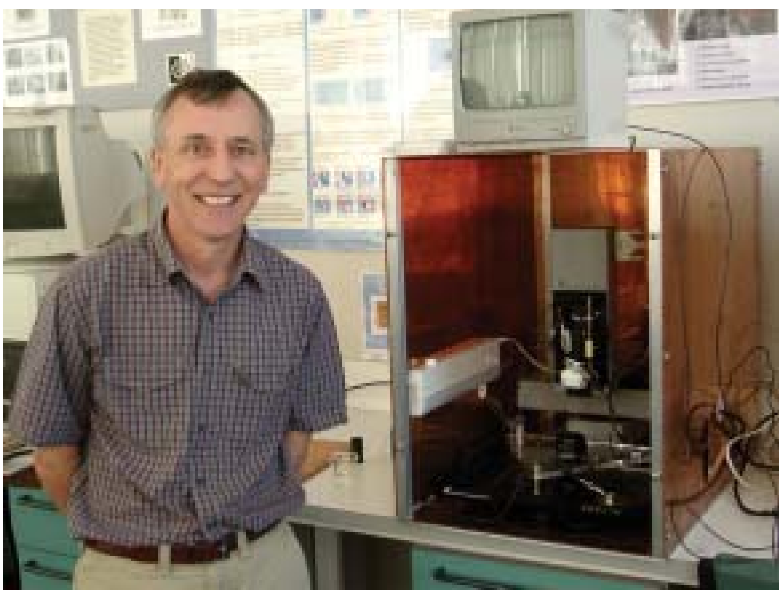
Sean Brossia—Director of research at CC Technologies (Dublin, Ohio), Brossia is interested in the application of corrosion, electrochemistry, and materials fundamentals along with technology to solve engineering problems. His company develops pipeline, oil and gas, energy generation, automotive, aerospace, and biomedical applications. Brossia's current research projects include defining the safe operating chemistry to prevent localized corrosion and stress corrosion cracking in underground nuclear waste storage tanks, a study of rouging (development of films on normally passive stainless steel), and restoration of artifacts from a Civil War-era shipwreck.

Roland De Marco—Head of the applied chemistry department at Curtin University (Sydney, Australia), De Marco specializes in corroding metals, sensors, and fuel cells. He's investigating the influence of water layers in solid-contact polymeric ion sensors (the physics and chemistry governing the formation of robust internal solid contacts are poorly understood, and new information is vital to widen the use of these sensors). De Marco is also examining the adsorption of micelles (structures of polymeric molecules or ions) onto solid substrates with a view to enhancing our understanding of the efficacy of corrosion inhibitors.

Florian Mansfeld—Professor of materials science and engineering within the Viterbi School of Engineering at the University of Southern California (Los Angeles, California), Mansfeld is investigating microbially induced corrosion, along with environmentally safe corrosion inhibitors and corrosion in composites. He is very interested in finding substitutes for toxic chemicals in corrosion inhibitors and coatings. He's also investigating the use of microbial biofilms as corrosion protection, along with the potential of microbes in fuel cells.

Harovel Wheat—Associate professor of mechanical engineering at the University of Texas (UT) (Austin, Texas) and a member of the university's Texas Materials Institute, Wheat has a particular interest in the corrosion of structural materials such as reinforced concrete, as well as the corrosive properties of grouts and fuels. She is investigating alternative reinforcements for concrete, nondestructive methods of assessing the corrosion of steel within concrete, and smart coatings that fluoresce or lose fluorescence in response to corrosive activity.

These five were kind enough to tell us a little about who they are, how they got started, and what goes on in their daily lives.



Robert Akid with the scanning droplet cell, a microcapillary device that delivers constant flow, which was developed in his lab. Photo courtesy of David Greenfield.

Roland De Marco on duty within the BIGDIFF diffractometer at the Photon Factory in Tsukuba, Japan, tending to his in-situ electrochemical cell. Photo courtesy of Arie van Riessen.

Early Interests

To get to know these investigators a little better, we asked them first about their early scientific interests. And we found a few surprises—certainly none of them started out with a passion for corrosion.

Mansfeld, for example, had no interest in science at all as a child.

"I wanted to be a historian," he recalls. But by the time he entered college, paternal advice led him to study physics, and then chemistry. His course was firmly set when he did his post-doc work in H.H. Uhlig's corrosion lab at Massachusetts Institute of Technology (Cambridge, Massachusetts). During that time, his perspective changed from "rust? how dull" to an undying interest in the electrochemical processes of corrosion.

With e-mail answered and calls returned, Sean Brossia gets into the details of his research. Photo courtesy of CC Technologies.

It seemed as if the young Wheat was on a path for biology when she was a child. She remembers conducting experiments on hatching chicks, to see whether they would imprint[1] on a wind-up toy. And sometimes they did, at least until her family grew weary of her hatching chicks in the living room. As a chemistry undergrad, Wheat put in a stint as a research librarian at an oil company. It was there that she became interested in corrosion, going on to graduate school to study metallurgy.

No group of budding scientists would be complete without at least one wild card, and Brossia seems to have filled the bill.

[1]Imprinting takes place immediately after chicks are hatched; many birds imprint on the first organism they see upon hatching, responding to it as they would to their mother.

"My experiments were generally not very appropriate for my age," he says, "and often centered on trying to make black powder, how to combine different types of fireworks into super-fireworks, creating potato guns, and so forth. I became quite adept in this area and thankfully never caused any serious damage, set any major fires, or got myself or anyone else hurt."

De Marco was influenced by an Australian TV science show for kids and, while most of his early experiments were not so madcap, he did work with older friends to prepare hydrogen-filled balloons by reacting zinc metal with hydrochloric acid in a specially designed bottle. So perhaps it's just as well that he and Brossia did not grow up in the same neighborhood.

Akid was likely a little easier on his parents, as he had no early interest in scientific experiments, explosive or otherwise, although he was known to build a few bow-and-arrow sets along the way. Akid was led into corrosion by the merest chance:

"Following a game of football," he says, "I got talking to a friend who had started working for the steel industry as a metallurgical trainee. It sounded good, and that was the start."

Getting to Work

The scientist who can do research full-time is a rare and fortunate character. Most of our panel start the day much as you might—going through the morning's e-mail and messages. Within the universities, there are a number of other interruptions: classes to be taught, papers to be graded, and office hours for students who require guidance. There are proposals and grant applications to complete, papers to write, and literature to keep up with. And sometimes there are additional hats on those academic heads. Wheat, for example, is the undergraduate faculty advisor for mechanical engineering at UT; there are about 1,000 students in the program.

When our researchers do get to the lab, there are the goals and to-date results to consider and colleagues to consult with, then further action to plan. For Brossia, the lone "commercial" researcher in our group, the research day also begins with a review of goals and progress. Then it's time to put on the lab coat and fire up the equipment. And what an assortment of equipment there is to be seen in these labs.

"The scanning droplet cell," Akid says of a new instrument in his lab, "is our latest development in evaluating localized corrosion. This piece of equipment differs from other microcapillary techniques in that the corrosive liquid is constantly flowing over the surface, and therefore does not have the problems associated with static conditions."

As a researcher on the go, De Marco treasures his portable potentiostat, he says, because, "It allows me to bring my applied electrochemistry experiments to cutting-edge materials characterization facilities such as neutron and synchrotron sources."

Wheat is also partial to her potentiostats (although she doesn't lug them about), because in her reinforced concrete research, the real work begins when she starts to collect the electrochemical information. Mansfeld echoes the vote for electrochemical equipment as a lab essential, while Brossia, with his broad research interests, is less decisive.

"It could be a potentiostat that enables the determination of a metal-environment system to experience localized corrosion. It could also be a mechanical loading frame that facilitates evaluation of stress corrosion cracking," he says. "Even the water purification system is important as it provides a consistent, clean starting point from which to build different test solutions."

The Highs

While they may enthuse over a particular piece of lab equipment, what really gets these folks excited, of course, is discovery: The great aha! moment. And often enough, the best of these are deceptively simple. Take, for example, an experience Akid relates.

"Many years ago I was working in the telecommunications business, where relays were manufactured using deep-drawn Cu-Ni containers," he recalls. "These containers would suffer stress corrosion cracking due to the use of chloride fluxes in the brazing operation. I noticed that the configuration of the components could be changed by simply inverting a bracket and electron beam welding the unit. This eliminated the braze operation and solved the cracking problem!"

De Marco recollects a simple "discovery" that helped him solve a perplexing problem: "I was working on the problem of the peculiar corrosion chemistry of silver sulfide in aqueous media. I was perplexed by the apparently contradictory behavior of silver sulfide, as observed in my experiments. At one key moment during an intense brainstorming session in the laboratory, my eyes were drawn to the amber bottle of pure silver sulfide. I was compelled to pick up the bottle and read the label: 'silver sulfide is photosensitive and should be stored away from light.' At this point, I made the realization that the apparently anomalous reactivity of silver sulfide was due to its photochemistry, and this enabled me to unravel the problem."

And the Lows

Like any other activity, research has its frustrations as well as its rewards. Our researchers contend with struggles for funding, theories that lead to dead ends, and the simple lack of time to devote to the work they love best. Sometimes, they can even be frustrated by too much of a good thing.

"We recently had a project on alternative reinforcement for concrete and we were very hopeful that we would obtain results in a timely manner," Wheat says. "Due to the extremely good quality of the concrete, we did not see the anticipated deterioration in corrosion behavior of steel in actual concrete during the allotted time of the project. We carried out many tests on steel in saturated calcium hydroxide and simulated pore solution, but we wanted results in actual concrete."

Harovel Wheat among samples of steel and other reinforcements within concrete blocks. The Lucite® boxes constructed atop the concrete blocks allow controlled application of corrosives for testing.

Wheat takes the unexpectedly stellar performance of the concrete in stride, demonstrating another lab essential: confidence, tempered with a sense of humor.

"At the end of the project," she continues wryly, "we had more than 140 specimens remaining. We turned over half of them to the sponsor for continued monitoring and we were allowed to keep the other half. We are continuing to monitor and test our specimens. It is disappointing that we were not able to obtain the results in the time allotted, but in the long run I think that the results will be extremely valuable."

Florian Mansfeld (with Ph.D. candidate Esra Kus) stops to check the latest data on one of several research projects in his busy lab. Photo courtesy of USC Viterbi School of Engineering.

Looking Ahead

Materials science researchers are by nature forward-gazing folk, whether they're planning the next step in an experiment or considering what today's discoveries will lead to in the future. Our panel offers some very exciting ideas about what the near future may hold.

The application of nanotechnology for new corrosion-resistant coatings and materials gets a big vote, and indeed, we're already seeing these products enter the marketplace. "Smart" materials and coatings are also on the way—materials that sense environments or conditions and respond to prevent or repair corrosion.

And when the time comes to look back, how do our scientists want to be remembered? As contributors to their field, who approached their work with enthusiasm; as clever problem solvers; as tough but fair and decent people who consistently gave it their best. And undoubtedly, as Akid puts it, they will be remembered "by being missed." MP