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Advanced Materials in Product Failure Litigation

There are far more materials available today and they improve performance and allow things to be made that were previously unobtainable. These materials are often what are called "advanced materials," and include things such as the fiber composites of which aircraft are made. Advanced materials also include mundane things such as spray foam insulations and things that have been around for decades such as some roadway surfaces. Two common traits of advanced materials make investigation of their failures more complex and multidisciplinary: (1) their properties are often anisotropic (i.e. directionally dependent) and (2) the chemical process for their formation occurs as part of the manufacture of the item being made from them (i.e. net shape). This second aspect of advanced materials can make their use highly complex, especially when the combined chemical formation/manufacturing process is placed in the hands of non-technical people such as those in the building trades.

Investigating Advanced Materials

An investigation of an advanced material requires an understanding of the underlying chemistry and of the chemical process by which it is manufactured, but the diverse range of advanced materials and of their uses mean that the investigator will encounter a variety of chemistries and manufacturing processes. A good understanding of the chemistry fundamentals that underlie these processes makes it practical to investigate the diverse range of advanced materials. Although the specific chemical reactions may differ, the underlying thermodynamic and physical chemistry principles are broadly applicable, as are many of the chemical analysis techniques.

The chemicals from which advanced materials are made are often solutions of other chemicals that have been synthesized at an earlier stage, and the entire chain of reactions needs to be considered. It is also not uncommon to encounter proprietary formulations, and chemical analysis techniques are not always able to sufficiently unravel the complete nature of a proprietary formulation. Again, a good understanding of the underlying thermodynamics and physical chemistry enable this situation to be successfully addressed, and accurate estimates to be made.

The chemical processing step of the manufacturing process must also be considered, and this will vary widely from product category to product category. Aircraft part manufacture and spray foam insulations both involve what are called thermoset resins, which are polymer precursors that form an extensive network through an irreversible exothermic (i.e. heat producing) chemical reaction. In contrast, common plastic items are made from thermoplastic resins, which contain long chains of molecules that wrap around each other to form a solid at room temperature and that unwind and allow the resin to flow at much higher temperatures, which is a reversible process. Processing common plastics involves heating to a high enough temperature and cooling. Processing thermoset plastics involves a sequence of reactions at higher temperatures that have to proceed by a tightly controlled trajectory over time so as to achieve changes in viscosity at the right points in the process, which allows gases to be expelled and the part to be compressed under pressure.

<u>Experience and Case Study</u>

An illustrative example is a comparison of investigating composite aircraft parts and spray foam insulations. Dr. Fildes' work was the basis for establishment of Northwestern University's federally funded Advanced Materials Intelligent Processing Center.

Dr. Fildes has also conducted litigation related investigations of composites in aircraft that crashed, of spray foam insulation odors and fires, and of roadway asphalts. The first two of these items are made from thermoset resins that share a common underlying set of principles of thermochemistry and physical chemistry, but the synthetic nature of the resins differ, as do the manufacturing processes.

All thermoset resins cure through a sequence of simultaneous reactions. Investigation of aircraft composites tends to focus on strength and possibly on resin aging. Dr. Fildes' investigations often involve the thermochemistry of curing of aircraft resins, which requires the staging of the sequence of reactions to be tightly controlled so that specific viscosities are achieved at target times in the process to allow pressure to be applied to expel gases and to consolidate the part, both of which are critical to achieving high strength.

Aircraft parts are made by well-trained workers, using specialized equipment such as autoclaves and molding machines. In contrast, spray foam insulations are made by trades workers in uncontrolled conditions on the job site.

Dr. Fildes' investigations of spray foams often are concerned with odors and fires, and involve assessing the impact of installation procedures, the prevailing temperature and humidity, and the resin system chemistry, including the synthesis of precursors one to several steps removed from the installation.

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Dr. Fildes is uniquely qualified through experience and training to provide insight on the role of science and engineering in litigation. In addition to conducting highly successful technical investigations for high-stakes litigation involving a wide spectrum of metals and materials, chemical processes, and sensors and controls. He also organized and conducted over $26 million in funded projects including research, development, and collaborations involving Government labs, large companies, and leading universities. John was instrumental in establishing and served as co-Director of Northwestern University's federally funded Advanced Materials Intelligent Processing Center, which was a was a highly successful collaboration involving University staff and professors, McDonnell Douglas (now part of Boeing), the Office of Naval Research, the Naval Air Warfare Center, and the Naval Sea Warfare Center and small companies. He is a doctoral-level scientist who has 50 published papers, reports and presentations, and has 3 patents. John's credits involve:

- *John's pioneering work was the basis for formation of Northwestern University's federally-funded Advanced Materials Intellight Processing Center. John's R&D involved advancing the state of knowledge of the sequence of thermoset cure reactions and their relation to performance and again, and the development of models and model-based processing methods that were the basis for equipment tested by McDonnell Douglas, Northwestern, and a small composites company, Production Products – St. Louis.*
- *John has investigated the failure of composite aircraft prats, the relationship of process deviations to composite performance, the relationship of resin chemistry and installation procedures to spray foam odors and fires, the expansion and contraction of wood products, and chemical issues involved in roadway resurfacing processes.*

Our approach provides:

- ✓ *The quickest and best possible outcome.*
- ✓ *A unique opportunity for early resolution based on knowing 60% to 80% of what might ultimately be uncovered.*
- ✓ *Superior technical insight for even complex and multidisciplinary issues.*
- ✓ *A reliable basis for expert testimony that meets rules for admissibility established by the Supreme Court.*
- ✓ *A strategic advantage with corporate clients since they already appreciate that this approach improves outcomes and lowers costs through use of all existing knowledge and elimination of duplication.*

Our approach uses information research and analytics early in technically related cases and *establishes the* key *MAKE OR BREAK technical issues and everything that is known about them.* This approach requires someone who has the extensive experience with both contemporary R&D methods and litigation-related expert witness investigations so as to adapt the corporate R&D technical investigation process to the unique aspects of litigation expert witness investigations. Our experience to do this is reflected in our process to bring litigators the R&D technical investigation techniques that have revolutionized industrial R&D, providing litigators with the better outcomes and lower costs that industry has achieved in overcoming similar investigation challenges.

1. Define the Technical Issues – Inspections, insight from litigation parties, and broad literature searching are conducted to gather information from prior related cases, trade association publications, patents, manufacturer's marketing materials and reports, and Internet forums to establish the key technical issues.

2. Use Analytics to Establish What is Known About the Technical Issues – The data gathered above is analyzed with data mining and modeling to adapt the data and fill the gaps that always exist in litigation investigations.

(3) Reliably Define Testing Needed – The data that has been collected and analysis that has been done ensures that existing knowledge is not recreated, the remaining work is properly focused, and all involved parties understand the challenges, methods, and progress.

(4) Coordinate, Oversee, and Effectively Communicate – This approach ensures that the overarching technical concepts are effectively framed and communicated, and eases report preparation. The results are well supported, clear, and compelling even to people not knowledgeable of science and engineering.