



Locard's Exchange Principle: A closer look at forensic determination of stains on tile and tile assemblies

By Jennifer Ariss

Durability and cleanability are a few of the many reasons to select ceramic tile installations for a range of architectural scenarios. However, installations may become stained and whether you are the installer, the manufacturer or the consultant, positively assigning a causal agent can be a tricky business. Stains found on ceramic tiles and their assemblies can be caused by a wide variety of sources and can prove very difficult to positively identify the actual cause or scenario that created them.

Dr. Edmund Locard, widely attributed as the father of forensic science, stated “every contact leaves a trace.” Thanks to popular TV shows like “CSI” and “Bones,” the populace has an increased familiarity with the principle of forensics but perhaps also, an unrealistic sense of what can be easily (and

cheaply) accomplished using modern techniques. In this article we will look at the techniques, possibilities and challenges associated with determination of unknown stains.

Q. What causes stains on tile and tile assemblies?

A. The causal agent of stains is extremely varied. Inorganic salts are often a likely culprit and may be the result of deposition by water or even the precipitation of components in regular cleaners which then stubbornly cannot be removed. On outdoor installations, organic acids may be the causal agent, especially in damp conditions. Biofilms, gooey microscopic ecosystems of bacteria, yeast, moss and lichen, may actually cause very problematic stains as they adhere tightly to pore spaces in the substrate and unless killed thoroughly,

Above: XRF spectra

return after seemingly disappearing. In rare cases, setting materials and adhesives can work their way up in an assembly and cause surface stains on grout and eventually the adjacent tiles. Location, pH, site history and many other factors contribute to staining.

Q. What are some considerations that need to be taken into account for identification of stains?

A. Forensic analyses have some distinct limitations. Contrary to what we are led to believe by watching CSI, there is no piece of equipment that a sample can be fed

into that then spits out the exact identity of the unknown compound. The reality is that most techniques can only positively identify an unknown substance if it can be matched to its source. Determination of the staining compound is most easily accomplished if there is a probable compound already identified. When TCNA performs this type of testing, we typically ask for samples of the stained substrate as well as samples of unstained substrate.

Analysis of an unknown sample without a comparison to a known sample can only predict a probable causal agent. Some compounds lend themselves to this type of treatment better than others, such as hydrocarbons because of their unique chemical profiles.

Q. What are some of the techniques that may be employed for determination of stains?

A. Determining the appropriate technique depends greatly on the type of stain and the type of substrate that is

stained. For example, causal agents of some stains may be identified using a sol-

Before you contract testing, make sure you understand what format your results will be returned in and to what degree the laboratory will support you with the interpretation of your results.

vent-based digest of the stained substrate followed by some type of chromatogra-

phy. Chromatography may be conducted in gas or liquid states and the result is a graph of how long the components of the sample are detectable under a specific set of conditions such as heat or adsorption to a known matrix. Detectors used in chromatography come in many different forms but some common examples are HPLC (high pressure liquid chromatography), PID (photo ionization detector), and ECD (electron capture detector). Compounds produce a unique chemical signature (like a chemical fingerprint) that can then be compared to a database and matched to known compounds.

Spectroscopy techniques are based upon the emission, absorption, or scattering of electromagnetic radiation. As with chromatography-based techniques, individual compounds provide unique profiles of how they respond and interact with electromagnetic energy. Some popular techniques used by TCNA employing this type of analysis are FTIR (Fourier



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transformed infrared spectroscopy), XRF (x-ray fluorescence), XRD (x-ray diffraction), NMR (nuclear magnetic resonance) and AA (atomic absorption). Some x-ray spectroscopy techniques are coupled with scanning electron microscopy (SEM) to provide analysis of crystalline structure and compound identity. SEM-EDS (electron dispersive spectroscopy) and XPS (x-ray photoelectron spectroscopy) are a few examples of these combined techniques.

Q. What are the limitations to forensic testing of stains?

A. Let's be realistic. Clients looking for these types of testing services are not doing so for their own edification. They are looking to establish responsibility, fault and who is going to pay to have it fixed. Litigation may even be involved. Be sure that the lab you contract with to do this type of testing has experience with the procedures and can provide you with a layman's explanation of the testing methods and how to interpret the results. Depending on the scenario and test methods used, the test report may include a definitive identification of the causal agent of the stain. However, more likely, the test report will include language like "consistent/not consistent" and "shares chemical similarity." Or worse, you could get back a chromatograph that bears a striking resemblance to a four-year old's hand-drawn rendition of the Alps. Before you contract testing, make sure you understand what format your results will be returned in and to what degree the laboratory will support you with the interpretation of your results.

Forensic determination of stains can be a frustrating process. However, it can lead to successful results with limited frustration if you keep the following points in mind. Have reasonable expectations. Carefully select a laboratory to conduct the analyses and feel free to ask plenty of questions. Consider hiring a consultant to not only interface with a laboratory but who can also evaluate site history and narrow down probable causes.

Finally, recognize that for this specialized type of testing service, answers don't always come cheaply or quickly. **TILE**



Jennifer Ariss

About the Author

Dr. Jennifer Ariss is the Research and Standards Development Scientist at Tile Council of North America. She is responsible for developing and modifying industry standards, assisting with TCNA's Green Initiative, and handling research projects for TCNA members and TCNA's Product Performance Testing Lab. Dr. Ariss has extensive experience in research, experimental design, and statistical analysis and is widely published in scientific journals.