Forensic Science Insights

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Volume 1 June 2018 Issue 6

Chemical Burns

Chemical burns are identified as an irritation or destruction of human tissue when exposed to a chemical substance. These types of burns can happen by direct contact with a chemical and/or through contact with its fumes. Chemical burns are complex and can continue to injure a person after the initial contact or symptoms may not develop until hours after exposure. Many people associate chemical burns with accidents at the workplace, but exposure can occur anywhere, including homes, schools, retail businesses, etc. Many household items and everyday products, including cleaning products, medications, personal products and/or consumer items can be responsible for chemical burns. In many cases, lack of safety equipment or proper instructions, improper labeling, handling, use and/or storage can contribute to chemical burns.

Injuries from chemical burns can range in severity depending on the concentration and pH of the material, the route of exposure, and the length of exposure. In some cases, chemicals can generate significant amounts of heat when exposed to air, water, or other chemical compounds. This can complicate treatment and advance the thermal and chemical injuries.

Alkali burns

Alkali materials, also known as strong bases, can neutralize acids, have pH levels greater than 7.0, are soluble in water and are corrosive. Some examples of alkalis that can cause chemical burns include lime and mortar products, drain cleaner, oven cleaner, fertilizer, ammonia and bleach. Sodium hydroxide is a common alkali and is used to manufacture many products such as soap, petroleum products, cosmetics, paper and explosives, to name a few. Depending on the concentration, alkali products can cause very serious burns in a short period of time.

When tissue is exposed to concentrations of certain alkalis, a process called saponification and liquefactive necrosis begins. Saponification occurs because alkalis not only denature proteins, but also break down fats. The outer membranes of cells are composed of fats that are broken down by the alkali compound. The cell begins to be destroyed. Liquefactive necrosis begins and the cells liquefy and dissolve. Pockets of liquid and/or pus-like fluid allow for the alkalis to travel and penetrate deeper within the body. This can allow damage to areas deep within the tissue, including bone and internal organs. Inhalation, ingestion and chronic exposure can also cause serious effects to the respiratory and gastrointestinal tract, including death in some cases.

Hypochlorite burns

Sodium hypochlorite is a liquid often used as a bleaching agent or disinfectant and can be found in consumer and commercial bleaches, cleaning solutions, and disinfectants for drinking water, wastewater and swimming pools. It is a strong oxidizer and is corrosive. If mixed with acidic solutions, toxic chlorine gas is produced, and mixing with ammonia-based solutions gives rise to chloramine solution, both of which can have toxic effects. Calcium hypochlorite is a solid, pellet or powder with a chlorine odor and is used to kill bacteria and/or algae. It is often used in swimming pools. Both of these hypochlorites can cause chemical burns to the skin and also respiratory damage if inhaled. Ingestion may cause burns to the mouth and throat, gastrointestinal irritation, vomiting and in some cases death. Any dermal contact with hypochlorites will start a hydrolysis reaction of that area. Hydrolysis is the process of using water to break down a molecule into two parts (reaction with water). Dermal contact with hypochlorites can result in a slippery or slimy sensation to the skin. This is due to the hydrolysis reaction in the top layer of the skin. Cells in that layer are breaking down and dissolving (saponification).

Organic Acids vs. Mineral Acids

Organic acids are organic compounds that have acidic properties and are categorized as weak acids. As organic compounds, they will contain carbon atoms. One of the most common organic acids is carboxylic acid, which has the molecular formula RCOOH. Other common organic acids include acetic acid (simplest form), citric acid, sulfonic acid and alcohol. In general, organic acids are weak acids and do not totally dissolve in water, but are soluble in organic solvents. Organic acids can be corrosive to skin and mucous membranes and can cause deep-seated burns on contact with the skin.

Mineral acids, also called inorganic acids, are derived from inorganic compounds and do not contain carbon atoms in their molecular structures. In general, inorganic acids are more hazardous than organic acids. These acids are categorized as strong acids, are highly soluble in water and tend to be insoluble in organic solvents. Some examples include hydrochloric acid, sulfuric acid, hydrofluoric acid and nitric acid. Mineral acids are corrosive and can cause severe irritation and burns to skin, eyes, mucous membrane, and the respiratory tracts. They tend to injure tissues by dehydration and heat production which can result in cellular death. Inorganic acids are hazardous acids that can lead to death if ingested.

Acid burns

A large number of household, commercial and industrial products contain acids at concentrations that can cause chemical burns. Acids have a pH below 7 and the lower the pH value, the stronger the acid. Sulfuric acid, hydrochloric acid, nitric acid and oxalic acid are some examples of acids commonly found in household or commercial products, or used in manufacturing products. When an acid comes in contact with tissue, it begins the process of coagulative necrosis. This process begins at a cellular level. Proteins found in skin cells undergo a change in their chemical structure when in contact with an acid. This changes the shape of the protein and it essentially stops functioning. In the case of acid contact with tissue, the cells die but do not liquefy as with alkaline burns. This coagulative necrosis leaves skin dead and usually white or clear in color, although burns from sulfuric acid will turn skin black. The dead skin provides a protection and can prevent the acid from penetrating deeper into the underlying tissue.

There is an exception to an acid's mode of coagulative necrosis to the tissue. Hydrofluoric acid is a dangerous strong acid that will result in liquefaction necrosis when in contact with tissue. Hydrofluoric acid can dissolve and penetrate deep into tissue before releasing hydrogen ions. This can cause extreme damage to cells and tissue beneath the epidermis, including bones. Liquefaction necrosis can occur well below the skin surface and can be some of the most horrific and difficult to manage/treat burns. Hydrofluoric acid is used for many industrial purposes such as glass etching, metal cleaning, and rust removal but also can be found in homes in rust removers and metal cleaners, especially aluminum metal cleaners.

Chemical burn incidents can be highly complicated and may involve a series of chemical interactions and/or reactions. In many cases improper storage, labeling of chemicals, lack of safety training and proper protective equipment contribute to chemical burns. Experts used in these types of cases need to have expertise in a variety of areas of chemistry, including reaction chemistry, hazardous materials, chemical labeling, health and safety, environmental chemistry and laboratory testing. The team at Gossman Forensics has the specialized knowledge that will properly evaluate and identify the details in a chemical burn case. We have the expertise in conveying these complex details in a meaningful, understandable expert report and/or to a jury.

Forensic Science Insights is a publication by Gossman Forensics, a division of ChemRight Laboratories, Inc. Please contact David Gossman, Chief Investigator, at 563-652-2822, by email at dgossman@gossmanforensics.com or visit us on the web at GossmanForensics.com.