

person's hair, body, and skin. The main advantage of this raw material (water) is the speed with which it can be initiated by the first responders using fire apparatus that is generally readily available. First responders are organized to prepare a channel of water as a ladder pipe system, with the major drawback being the unheated water (20, 28). Water is used in mobile units of decontamination (MUDs) and may be heated with adapted systems; the major drawback is that installation on the crime scene needs time (around 30 minutes), even for trained firefighters. Temperature and time to shower are standardized to an optimal decontamination method (20, 61). It is relevant to consider the issues after decontamination by water. Mechanical washing may more or less remove hydrophilic viscous products; however, viscous hydrophobic substances are more difficult to remove. Water helps with the physical removal of chemicals and hydrolysis, i.e. sulfur mustard (18). Water can exacerbate skin lesions caused by sulfur mustard. Viscous and oily substances, difficult to remove mechanically, may be wiped on the the surface of the skin before decontamination. Water may enhance the dermal absorption of certain chemicals, a phenomenon known as the W-I effect (62). In some regions of France, the formal process of wet (showering) decontamination is often preceded by dry decontamination of casualties using FE (*gant poudre*). This can more rapidly achieve the initial decontamination and may assist in reducing gross contamination prior to showering (63).

#### 24.6.6.2 Detergents

Detergents and soaps decrease surface tension, increasing the solubility and viscosity of the agents (64, 65). Surfactants that affect the permeability characteristics of several biological membranes, including skin, may solubilize SC lipids. Despite the fact that surfactants are considered chemical-penetration enhancers, especially by the transdermal route (66, 67), they are used in skin decontamination (68). The European project, the ORCHIDS protocol, consists of a 1.5-minute shower with a mild detergent, Argos, supplemented by physical removal (69). This soap is composed of anionic substances, alkyl benzene sulfonate sodium alkyléthersulfate sodium, nonionic, diethanolamide de coprah, and adjuvants (48). The role of surfactants, largely developed in decontamination processes, must be evaluated before skin utilization (62, 65, 70). According to their nature—anionic, cationic, nonionic, or zwitterionic—their potential enhancement effects could be assessed (71). A surfactant is a chemical that mixes readily with both oil-like and water-like chemicals. This include soaps, detergents, emulsifiers, and wetting agents.

### 24.6.7 SPECIFIC TECHNOLOGIES

#### 24.6.7.1 Neutralization

Neutralization is a process of chemically reacting an agent to form other, less toxic chemicals. Four main types of chemical reactions are involved in neutralization: (1) substitution, (2) oxidation, (3) chelation, and (4) enzymatic and biodegradation. Neutralization was initiated by Lewis in 1959, who recommended initial copious water skin decontamination followed by neutralization of acid skin splashes with a solution of weighed sodium bicarbonate ( $\frac{1}{2}$  ounce; 14.2g.) or 1% of sodium citrate for alkaline skin splashes, followed by more copious amounts of water (72).

##### 24.6.7.1.1 Neutralization by Substitution

Neutralization by substitution is essentially performed by water hydrolysis, with a nucleophilic active decontaminant developed in the reactive skin decontamination lotion (RSDL) (73).

##### 24.6.7.1.2 Hydrolysis

Substitution by hydrolysis depends on pH, which may be increased by modification, depending on the agent and the media. Hydrolysis takes place at any pH, but some hydrolysis products are still dangerous but less toxic e.g. G agents hydrolysis leads to methylphosphonic acid and hydrogen fluoride (HF) (74). Sulfur mustard hydrolyzes slowly to form thiodiglycol (TDG) (75, 76). The products of hydrolysis must be considered in the decontamination process.