VI. WORK PRACTICES

Occupational exposures can occur in the manufacture of solid forms of acrylamide [19,23], in the preparation and utilization of aqueous solutions of acrylamide [16], in the polymerization process [20], and in the handling of polymerized products which contain the residual monomer [17,18].

The conventional way of cutting bags of solid monomeric acrylamide manually with a knife and dumping the pellets or flakes into the reactor for polymerization should be replaced with a method that limits exposure to acrylamide. One method that has been used is a mechanized, maximally enclosed, or ventilated system [57 (p 135)]. The only manual step in this process involves placing the bags on the cutter; the rest is handled mechanically. The bags are cut open automatically and the solid acrylamide is dropped by gravity into the hopper of a bin. Any dust or vapor may be controlled by a canopy-type local exhaust ventilation and trapped by a filter. The empty acrylamide bags are transferred on a moving conveyor to a compressor, where they are compacted and automatically inserted into plastic bags for disposal. There is less chance of acrylamide escaping in this system if the hopper is connected directly to the reactor.

The trend of some manufacturers to replace solid crystalline forms with aqueous solutions of monomeric acrylamide has warranted special work practices in handling the liquid form. Because of the high dermal hazard of the aqueous solution of acrylamide, liquid acrylamide should be transferred from the truck to the storage tank and from the tank to the reactor in closed-line systems [57 (pp 134-35)]. If pressure buildup is a problem, then the tank should be equipped with an alarm system to signal any internal pressure buildup so that corrective measures or evacuation of the area may be accomplished as needed [57 (p 135)]. Filters installed on top of the storage tanks should be routinely checked and replaced as necessary. Safety features on the tanks should also be checked regularly and corrected when found defective. Precautions should be taken for line opening and tank entry [57 (pp 58-59),76]. Before opening up a line, the worker or workers should set up a barricade to isolate the area and check the condition and location of the nearest eyewash fountain and safety shower. All workers involved in this operation must be supplied with whole body protection, including air-supplied respirators (self-contained or airline). This protective equipment should be worn when entering the tank unless it is known that entry into the tank is safe. A second properly protected worker must be on standby outside the tank [76].

In addition to sound engineering controls, work practices should emphasize personal protective devices, good housekeeping, and personal hygiene. To minimize dermal contact with solid or liquid acrylamide, all workers and nonworkers entering work areas should wear protective clothing including long-sleeved coveralls, head covering including face shield (8-inch minimum), protective footwear, and impervious gloves or neoprene gloves with cotton liners [57 (p 6)]. Soiled protective clothing provided at the beginning of each work shift should be left in bins at the workplace for laundering after work. Protective and personal clothing should be kept in separate lockers [76].

If there is any chance of skin contact with acrylamide, then the protective clothing worn should be impervious to acrylamide. At the present time, the suitability of impervious clothing for the protection of the worker has not been adequately established. In addition, it is difficult for workers to wear this clothing for extended periods of time. These factors emphasize the need for showers, eyewash fountains, and proper engineering controls.

Protective clothing and some polyvinyl chloride (PVC) coated gloves have shown a wide variation of permeability to acrylamide [77]. Of the different types of gloves tested for resistance to penetration in an 8-hour test period from a 50% acrylamide solution, the Edmond Snorkel Vinyl-coated glove has been reported to have low permeability to acrylamide, whereas PVC-coated gloves have proven to be more permeable to acrylamide. Therefore, to ensure employee protection against dermal acrylamide exposure, all protective clothing and glove types should be first tested for their permeability to acrylamide before being worn. For further dermal protection against acrylamide, all protective clothing should have a cotton lining for comfort.

Impervious gloves with separate cotton liners and impervious long-sleeve overalls must be worn when handling equipment or containers used in acrylamide operations. The gloves should be either gauntlet type or long enough to overlap the sleeve [57 (pp 48-51),78]. A supply of these gloves should be on hand in the workplace. After work, the outside of the gloves must be washed before removal from the hands; if contaminated on the inside, hands must be washed immediately and the gloves should be replaced by a clean pair. Since eye irritation has been reported in acrylamide operations [1] and acrylamide is volatile [1,3,4], chemical safety goggles [76] should be worn in operation areas. Face shields are required in addition to chemical safety goggles during line openings involving liquid acrylamide [76]. Eyewash fountains and emergency showers also should be available in acrylamide work areas [57 (p 6)]. It has been reported [3] that acrylamide monomer is neither an explosion nor a fire hazard when stored at room temperature.

Solid acrylamide wastes, including compressed contaminated bags, drums, drum liners, or containers should be disposed of either by burial in an approved landfill away from drinking water sources or by burning in an approved industrial incinerator [76]. Decontaminated liquids or any aqueous acrylamide waste solutions should be drained to a sump for subsequent treatment by an approved facility.

Good housekeeping must be instituted to minimize the hazards of acrylamide inhalation. Floors constructed of concrete in operation areas should be sealed with a layer of impervious material to prevent the trapping of acrylamide that may otherwise occur and to facilitate the removal of spills [57 (p 135)]. Certain types of epoxy resin floors are the most impervious to acrylamide penetration [77]. Thorough testing should be conducted to investigate varying degrees of acrylamide penetration through the epoxy resin floor covering before any epoxy resin or other material is used as an impervious floor covering. Coroline 505 (an epoxy resin) is said to have a high degree of resistance to acrylamide penetration as a concrete floor covering. Other floor covering formulations may also be effective. When spilled, solid acrylamide should be either wet vacuumed or mopped up immediately and deposited in a covered drum [57 (p 135)]. One quart each of 1.6% potassium persulfate solution and 1.6% sodium metabisulfite solution should be mixed and used to decompose each pound of acrylamide in the drum [57 (p 22)]. After 30 minutes, the contents of the drum should be properly disposed of. The residual acrylamide on the floor should be mopped with a mixture of 3 gallons each of potassium persulfate and sodium metabisulfite for every 250 square feet of floor area and the liquid residue should be properly disposed of. Any acrylamide spilled on the surface of equipment should be removed and transferred to a covered drum and treated as described for floor spills. Contaminated equipment surfaces should be washed with a mixture of potassium persulfate (1.6%) and sodium metabisulfite (1.6%) solution by a worker wearing impervious long-sleeve overalls and rubber gloves. The floor area adjacent to contaminated equipment should be treated with the mixed solution.

Good sanitation and personal hygiene practices should minimize the risk of acrylamide ingestion. Hands should be washed before drinking, eating, or smoking. Food and beverages consumption or smoking should not be allowed in any acrylamide work or storage areas. Showering is recommended after each work shift [57 (pp 6,46)] before leaving the workplace where acrylamide is handled.

For emergency conditions such as spills and leaks, full body protection, including an air-supplied respirator, must be worn [76]. If the eyes come into contact with acrylamide, they should be immediately flushed with low-pressure flowing water for at least 15 minutes. Any skin contacting acrylamide should be immediately washed with soap and flowing water. Vomiting should be induced if acrylamide is ingested and the worker is conscious. A physician should be contacted immediately. Employees, physicians, and other medical attendants should be informed of the possibility of delayed neurologic effects. All employees should be trained and verbally informed about accident and first-aid procedures and use of respirators. They should also be informed of the hazardous areas, with special instruction given to illiterate employees.

VII. RESEARCH NEEDS

Two routes of entry, dermal and inhalation, are of major concern in occupational exposure to acrylamide. Only two animal study reports have briefly described the absorption [37] and toxicity [34] aspects of acrylamide after dermal applications. No inhalation studies on humans or animals have been found to date. The toxicity in animals of acrylamide administered by dermal and inhalation routes should be investigated as this chemical exists as an aerosol or vapor in the industrial work environment. Such studies should involve investigation of both short- and long-term effects.

No epidemiologic report on acrylamide has been found in the literature to date. Such studies are needed to provide information on occupational exposures to acrylamide and to determine the relationship between airborne concentrations and observed effects on humans. No human or animal studies have been found in the literature regarding the possibility of carcinogenic, mutagenic, or teratogenic or other reproductive effects of acrylamide. However, Hashimoto and Aldridge [38] have observed a low level of incorporation of iv-administered 14C-acrylamide in the DNA and RNA of rat brain and liver. These observations and the fact that acrylamide bears a structural resemblance to other biologically active compounds, including a known carcinogen, vinyl chloride, would suggest that acrylamide may produce mutagenic or carcinogenic effects in mammaliam systems. However, there is insufficient information to draw any conclusion at this time. Research efforts should be initiated in these areas to answer these important questions. Studies are now being conducted by NIOSH to investigate any mutagenic potential of acrylamide.

Although the effects of acrylamide on the CNS are suggested by the results of human [21,22] and animal [39,42,52] studies, the extent and reversibility of the changes after short-term exposure, and the structural damage after prolonged, low concentration exposure are not clear at this time. Further research is therefore indicated in this area. Except in a few studies [34,47,55], acrylamide has been used by various workers as a tool for investigating its mechanism of action in causing peripheral neuropathy in experimental animals. Toxicologic information on other physiologic systems (such as cardiovascular, renal, hepatic, and pulmonary) is lacking. Detailed investigations of the effects of acrylamide on these organ systems in animals need to be done.

Available information on the pharmacokinetics of acrylamide is inadequate. It is not known whether the toxicity of acrylamide is from the parent compound or its metabolite or metabolites. The half-life of acrylamide in the blood, plasma, and in various tissues along with fecal and urinary excretion rates should be investigated. Interdisciplinary studies are needed to determine the metabolic/biochemical basis for neurotoxicity and why the distal parts of central and peripheral nerve fibers are most vulnerable to systemic acrylamide intoxication.

At present, no sensitive tests are available for early diagnosis of adverse effects to acrylamide. There is a need to develop a sensitive, practical, and economical test for this purpose. Research efforts are in progress to develop such a test at Albert Einstein College of Medicine of Yeshiva University.

Tomcufcik et al [10] found that various acrylamide compounds inhibited the growth of tumors in mice. Ismaylova [11] also found the same inhibition property in tomato plant tumors and Ismaylova et al [12] in plant tissue cultures. This property might be interesting to investigate in mammals.

The recommended impinger sampling method for acrylamide has several disadvantages when used for personal monitoring. These include breakage of the glass impinger and spillage of the absorption solution during sampling and subsequent shipment to the laboratory unless extreme care is taken. A method of personal monitoring using a membrane filter followed by a silica gel tube or other adsorbent tubes should be evaluated. The efficiency of the method sought should apply equally to the collection of both acrylamide dusts and vapors. Differential pulse polarography and gas chromatography are the commonly used analytical techniques for the determination of acrylamide in the industrial environment. Differential pulse polarography requires validation of its reliability and reproducibility while gas chromatography needs the development of an improved derivatization technique.

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