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ANALYSIS OF APPLICATIONS OF SOLAR TECHNOLOGY FOR THE TREATMENT OF CHLORINATED ORGANIC WASTE

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ABSTRACT

Recent work has demonstrated that concentrated solar energy can destroy many hazardous chemicals that are of national concern including dioxins, polychlorinated biphenyls (PCBs), and chlorinated solvents. A detailed systems analysis was performed to determine the applicability of solar detoxification to the treatment of chlorinated solvents. This work determined the cost of destruction of trichloroethylene (TCE) a using conventional and a solar-based technology. The cost of solar detoxification and that of the conventional technology were compared for this application. This work provides a basis for choosing an application in which solar energy can be used to its fullest potential to solve a growing national problem.

INTRODUCTION

This century has been characterized by an ever increasing use of resources and, as a result, an ever increasing production of hazardous wastes that accumulate in the air, water, and soil. In recent years, the number of sites considered hazardous under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) has increased sharply from approximately 9,000 in 1980 to more than 27,000 in 1989 (1). Manufacturing facilities continue to release toxic chemicals to the air and water. In 1988, 2.4 billion pounds of toxic chemicals were released to the air in the United States (2). In that same year, 310 million pounds of toxic chemicals were released as water discharges.

Organic wastes constitute a broad range of compounds that are found in soils and groundwater. Many of these substances are currently being produced and released into the environment. The wastes include chlorinated organics such as dioxins, polychlorinated biphenyls (PCBs), trichloroethylene (TCE), perchloroethylene, and methylene chloride. They also include nitrated organics such as trinitrotoluene (TNT) and its derivatives (3,4).

The Solar Industrial Technology Program is looking for industrial and environmental applications such as these for the solar thermal technology. This Department of Energy program is managed by the Solar Energy Research Institute (SERI) with research and development activities at both SERI and Sandia National Laboratory.

In determining a representative application for solar destruction, importance was placed on the quantity of waste that already exists in the environment, the quantity of waste that is currently being released into the environment, and the location of the waste, specifically the occurrence of wastes in the southwestern United States-Colorado, New Mexico, Arizona, Utah, Nevada, and California, the region of highest solar insolation.

Chlorinated organic solvents, as a class, were chosen for this analysis. A search of the National Priority List (NPL) showed that 31% of sites contained these contaminants in the states of Colorado, Wyoming, and Utah. A total of 63% of sites contained these substances in California, Arizona, and Nevada. A search of the Enviromental Protection Agency Toxic Chemical Release Inventory showed that a total of 13,000,000 lbs trichloroethylene, perchloroethylene, and methylene chloride are released annually from manufacturing processes to the atmosphere in Nevada, Utah, Arizona, and California.

Photochemical solar destruction of these types of substances must be based on a photocatalytic or photoinitiated process because these substances do not absorb in the solar spectrum. Photocatalytic and photoinitiated destruction are potentially applicable to mixtures and raise the possibility for dramatic reductions in the reaction temperature. These advantages will be discussed later.

A detailed systems analysis was performed to determine the applicability of solar detoxification to the treatment of chlorinated solvents. This work determined the cost of destruction of TCE using conventional and solar-based technologies. The variation of system cost with reaction conditions and waste characteristics was determined for the solar technology and compared to the cost of the conventional treatment technology.

CONVENTIONAL TECHNOLOGIES OF CHOICE

Chlorinated organic solvents are released from manufacturing processes into the atmosphere in the gas phase. In addition,