GLASS CLEANING AND CHARACTERIZATION OF CLEANLINESS

L. L. Hench and E. C. Ethridge

Ceramics Division
Department of Materials Science and Engineering
University of Florida
Gainesville, Florida 32611

The use of a number of different surface analytical techniques for surface characterization of glasses is outlined. Since glass surfaces react with the atmosphere producing surface films which are different from the bulk composition an understanding of the nature of these films is needed in order to understand the meaning of surface cleanliness. The five types of surfaces which can form on glasses are reviewed and examples are given. Glass durability tests require that the surface films be removed prior to testing. A procedure for characterizing the cleanliness of samples for durability tests is reported. The kinetics of silica rich film formation are presented as well as the effects of environmental solution variables on film formation and stability. The use of Auger electron spectroscopy to characterize the cleanliness of glass surfaces cleaned by various procedures is presented. It is demonstrated that sulfuric acid dichromate solution effectively removes surface contamination from glasses. Even for cleaned glasses that exhibit durable surfaces, interaction with water occurs within minutes and the resulting surface compositional gradients must be considered in subsequent use or study of the glass.
INTRODUCTION

The cleaning of glass surfaces is important to the food, pharmaceutical, health care, and electronic industries, for example. Glass cleanliness is also a vital topic from the viewpoint of the research community because of the common use of glass as a laboratory ware, containers, substrates for growth of cultures, and recently in potential applications for nuclear and thermonuclear sources of energy and as a replacement material for teeth, bones, joints and other parts of the body. Also, the maintenance, cleaning and restoration of glass antiquities and medieval stained glass windows is a subject of considerable importance to the historical and art community.

Because of the considerable interest in the production and characterization of clean glass surfaces a considerable volume of literature has developed. However, many of the early efforts in this field were hampered by the lack of scientific tools for analyzing the structure and composition of the glass surface at sub-micrometer depths. Methods for surface characterization of glass are now available and the objective of this paper is to review briefly the instruments required.

Much early work in the field of cleaning and contamination of glass treated the glass as an inert substrate with a composition equivalent to that of the average chemical analysis of the glass. By the use of surface characterization methods it is now well established that the glass surface at the \( \mu m \) level is usually of a composition significantly different from that of the bulk. A compositional continuum often exists between the outer surface and the bulk, or discrete compositional layers may even be present. Thus, a second objective of this communication is to illustrate the five major categories of surfaces that are observed to be present on glass of various compositions and indicate how the thickness of the surface films may be determined.

Cleaning and maintenance of glass cleanliness depends upon the type of surface present on the glass. If deep reaction zones of several micrometers are present, adsorbed species and contaminants may be contained within the microporosity associated with such deep layers. Cleaning such layers may require removing the glass reaction zone. Chemical removal of the contaminants or reaction zone is often difficult without producing further attack of the glass network which makes maintenance of the surface condition very difficult. Even glasses with very high chemical durability, such as soda borosilicate compositions, exhibit the problem of maintenance of a cleaned surface state to some degree. A third objective is to discuss the results of a study characterizing cleaning and post-cleaning reactions on a commercial soda