STUDIES ON THE EFFECTS OF IRRADIATION AND THERMAL CONDUCTIVITY ON SOME GLASSES CONTAINING IRON

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ABSTRACT

This thesis consists of two parts. The first part describes the absorption spectra of some borate glasses containing iron before and after being irradiated with gamma rays. The glasses were prepared from pure chemicals and the mixed batches were melted in platinum crucibles in an electric furnace at the appropriate temperature. Absorption spectra were measured for highly polished annealed samples before and after irradiating with gamma rays. The resulted spectra showed induced characteristic bands for parent blank glasses and glasses containing iron. The positions and intensities of the induced bands were shown to change with variation in chemical composition of the glass and with the irradiation dose. The color centers observed were attributed to originate from the effect of irradiation on the already present structural defects, interstices, multivalent impurities or nonbridging oxygens. Released electrons or holes might trap to such defects and new electronic configuration were believed to arise causing preferential light absorption or induced bands. The effect of the transition metal, prolonged irradiation and the change in chemical composition on the growth of induced bands were discussed.

The second part includes thermal conductivity studies on some alkali borate glasses and high lead borate glasses containing iron before and after gamma rays irradiation. The thermal conductivity was measured by the steady state for the glass discs (18 mm diameter , 5 mm thickness) using an apparatus designed specially and calibrated by standard sample from corning glass works, U.S.A. The experimantal results show that thermal conductivity increases with the introduction of a divalent oxide replacing soda and decreases with gamma rays irradiation. In high lead borate glasses, increasing Fe_2O_3 in the glass increases its thermal conductivity while increasing PbO decreases it. The results can be understood when it is realized that heat is conducted in glasses by phonons. The mean free path of a phonon is smaller when the glass network structure is disrupted. In otherwords, the thermal conductivity is said to decrease in a glass with the increase of the disordering of the network structure as a result of the shortening of the phonon mean free path.

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PART 1

SPECTROPHOTOMETRIC STUDIES ON SOME IRRADIATED BORATE GLASSES CONTAINING IRON.

1. INTRODUCTION

1.1 Radiation Chemistry

Radiation chemistry is the branch of chemistry which concern with the study of physical and chemical effects of high energy, ionizing radiation on materials. High energy radiation includes electromagnetic radiation (X-rays and γ-rays), particles (α-particles , B-particles or electrons, protons and neutrons) and fission fragments.

There is a characteristic distinction between radiation chemistry and photochemistry that radiation of high energy causes ionization in all materials. In radiation chemistry, only part of the radiation energy may be transferred at an interaction and the process is not selective. There is a sufficient energy to break any bound but in practice certain bounds may be broken preferentially. The ionizing photon or particle and the displaced electron are both capable of producing further ionization. Thus one incident photon may affect many thousands of molecules.

1.2 The Interaction of Electromagnetic Radiation with Matter[1,2]

From the physical point of view the interaction of X - or γ-rays with matter takes place according to the following three processes:

1.2.1 The Photoelectric Effect

In this process an incident photon ejects a loosely bounded electron from an atom or a molecule. This can happen whenever the energy of the photon is greater than the binding energy of the electron, and the energy of the ejected electron is equal to the difference between the incident photon energy and the binding energy of the electron.

In this reaction conservation of energy is possible through the imparting of some momentum to the remainder of the atom. As the photon energy increases,more tightly bounded electrons are ejected. The probability of interaction with a given electron is greatest when the energy of the photon is just slightly greater than the binding energy of such electron. The probability of photoelectric absorption increases rapidly with both decrease in photon energy and increase in the atomic number of the irradiated material . Except in the case of the heaviest elements, photoelectron absorption is rather insignificant for γ-ray energy greater than 1 Mev. In the photoelectric effect, the photoelectron are mainly responsible for the ionization produced by low energy photons.

1.2.2 Compton Effect:

This process is the result of elastic collision between a photon and an electron in which part of the photon energy is transferred to the electron and photon is scattered with reduced energy as shown in Fig.(1). The secondly photon travels in a direction different from that of the primary photon and is called scattered photon.

The compton effect is more important for photon energy in the range from 1.0 to 5.0 Mev. in elements of high atomic number and over much more extensive range of energies in elements of low atomic number. It is noteworthy that this is the major effect observed on using Co^{60} γ -radiation.

In the compton process for low incident photon energies, the scattered photon, will have very nearly the same energy as the primary energy and as the incident energy is increased, the fraction removed by scattering decreases and the electron receives an increasing share of the available energy.

1.2.3 Pair production

In this type of interaction, the primary photon disappears and its energy is transferred to a newly formed position and megatron pair. In this process, the incident

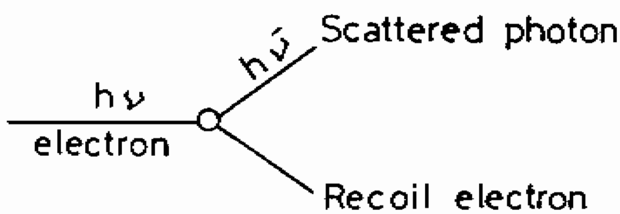

Fig. 1. The compton process

photon must have an energy larger than the total rest mass of the pair, i.e., larger than 1.02 Mev.

1.3. Effect of Radiation on Inorganic Solids

Defects are produced in the lattice structure of inorganic solids when it is exposed to radiation as the atoms or ions displace from its original position, and consequently it produces coloration and changes in the physical properties of the solid.

The term colour center was first given by Pohl[3]. It is usually applied to the special electronic configuration in a solid that gives rise to optical absorption in the visible or ultraviolet region. These configurations are:

(a) electron traps,

(b) hole traps, i.e., electron deficiencies.

1.3.1 The Electron Trapped Centers:

The classical example of these centers is the "F-center". This center is formed by the trapping of an electron at a negative ion vacancy. Fig.(2 a) is a schematic representation of a perfect portion of an NaCl crystal, while Fig. (2 b) represents a crystal containing a single negative ion vacancy. One of the electrons may be captured by this negative ion vacancy if the crystal was