ADDENDUM

Tables and figures of the paper: A.C. Conductivity in Briny TeO_2-MoO_3 glass which appeared on pp. 129-132, Yemeni J. Sci. 5 (2) 2004.

Table 1. The values of the frequency exponent (s) for different mixing ratios and temperatures of the TeO_2-MoO_3 glass system.

MoO_3 (wt%)	Temp (°C)	35	65	85	100	125	150	175
0	Exponent (s)	0.91						
10		0.886	0.8636	0.854	0.848	0.84	0.82765	0.818
20		0.89	0.8786	0.863	0.859	0.842	0.8335	0.826
30		0.91	0.90	0.89	0.886	0.8777	0.865	0.85
40		0.93	0.897	0.884	0.875	0.86	0.85	0.838
50		0.9	0.875	0.858	0.846	0.832	0.82	0.06
55		0.88	0.8518	0.838	0.827	0.806	0.79	0.783

Table 2. The values of the frequency exponent (s), (ß) and the density of states at T=35°C and f=1KHz of the TeO_2-MoO_3 glass system.

MoO_3 (wt%)	Exponent (s)	Exponent (ß)	N(E) 10^{15} ($cm^{-3}eV^{-1}$)
10	0.886	0.114	0.16301
20	0.89	0.11	0.77251
30	0.91	0.09	7.5105
40	0.93	0.07	34.19
50	0.9	0.1	300.66
55	0.88	0.116	1081.01445

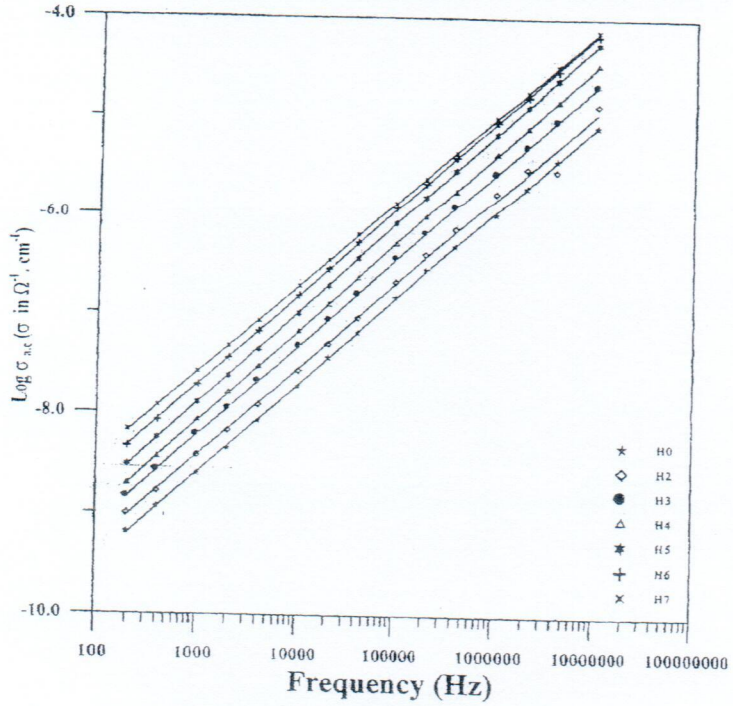
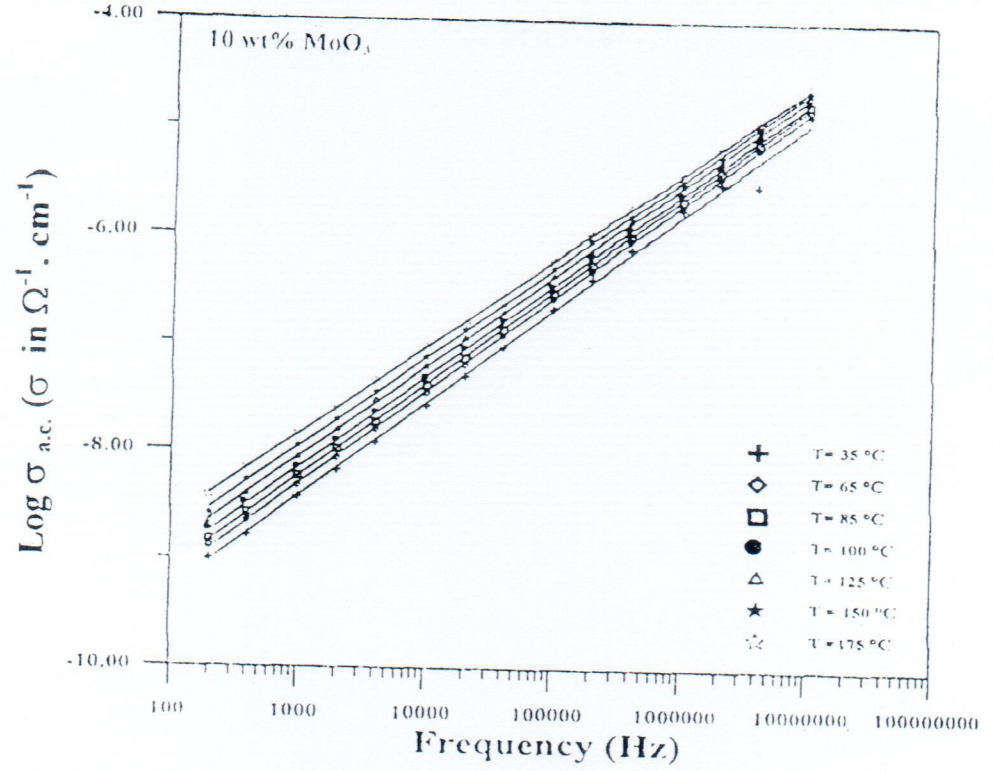


Fig. 1. The relation of log $\sigma_{a.c}$($\sigma in \Omega^{-1}$ cm^{-1}) versus frequency for all TeO_2-MoO_3 glass samples measured at T=35 °C.



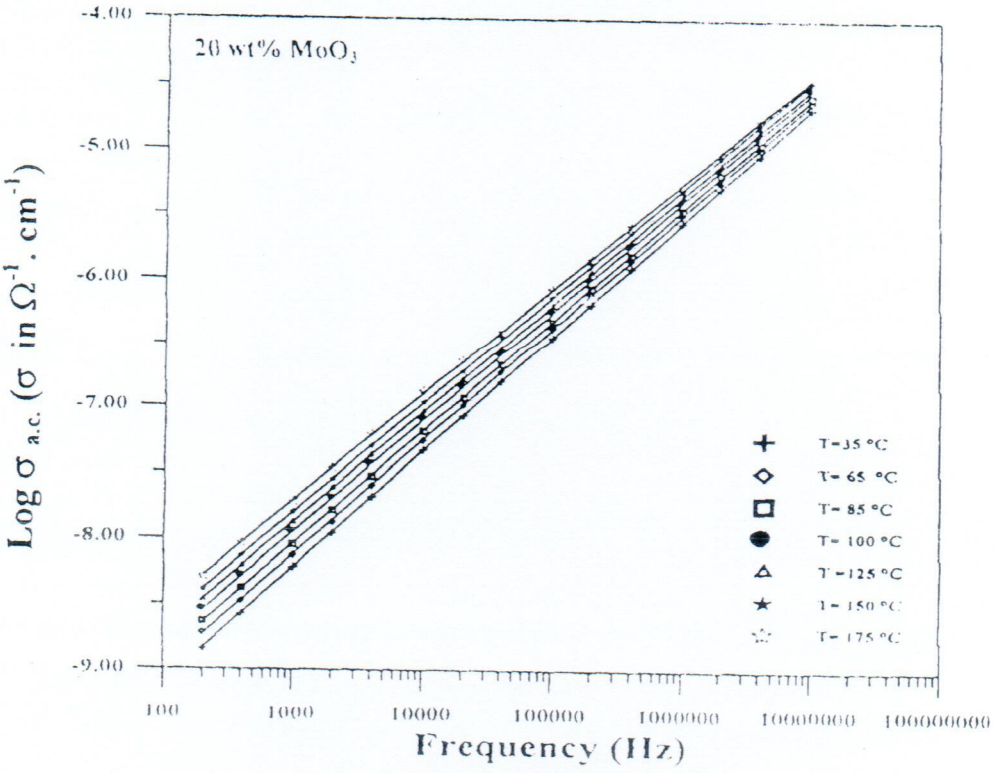


Fig. 2. The relation of log $\sigma_{a.c}(\sigma in \Omega^{-1} cm^{-1})$ versus frequency at different temperature for TeO_2-MoO_3 glass samples.

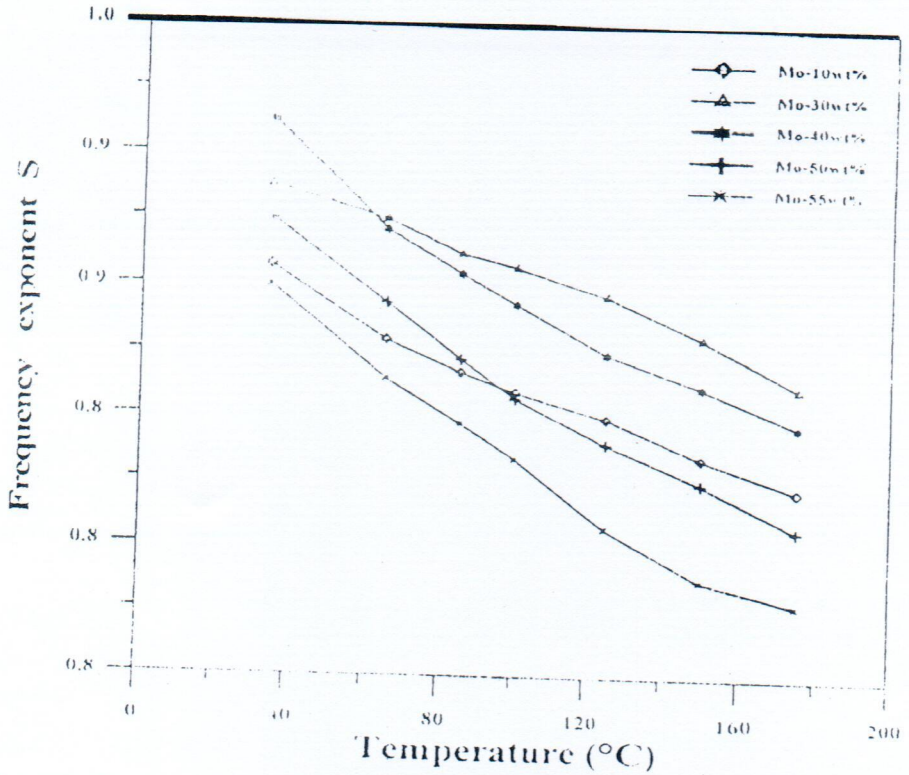


Fig. 3. The variation of the frequency exponent (s) with temperature for TeO_2-MoO_3 glass system.

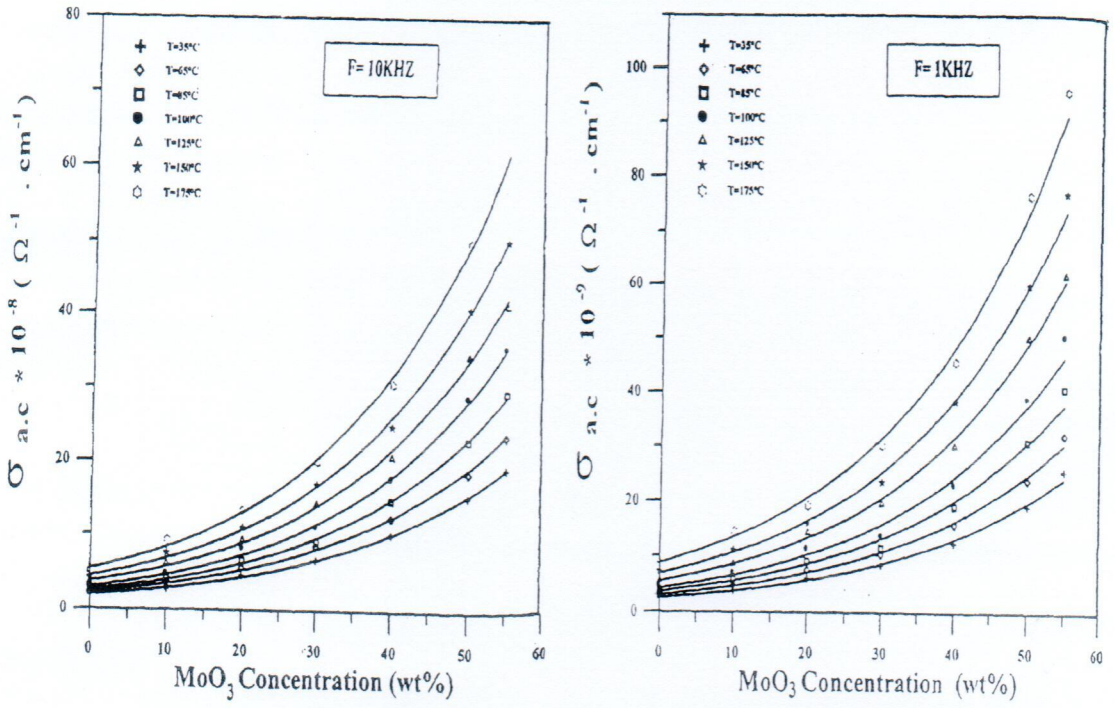


Fig. 4. The variation of the $\sigma_{a.c}$ with the MoO_3 concentration in the TeO_2-MoO_3 glass system measured at fixed frequency and different temperatures.

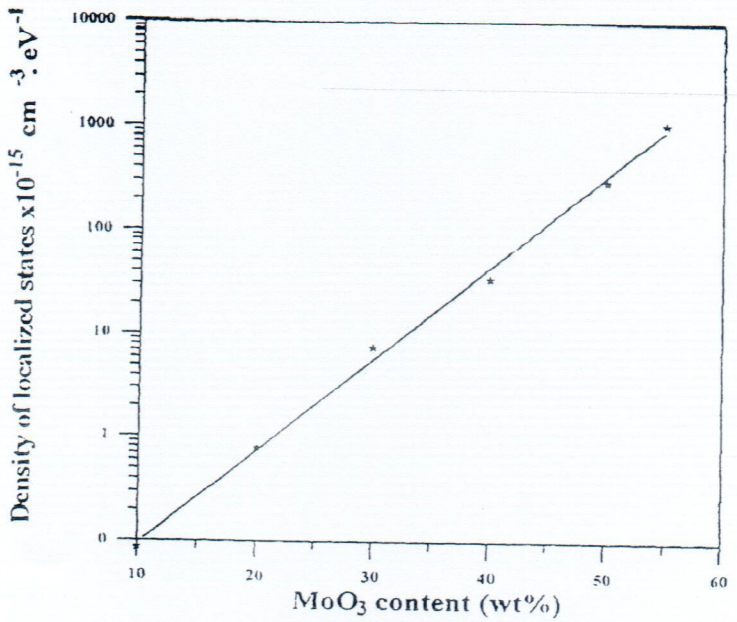


Fig. 5. The variation of the density of states N(E) as a function of mixing ratio of the TeO_2-MoO_3 glass system.

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A. C. Conductivity in Binary TeO_2-MoO_3 Glasses

S.K.J. A1-ANI, Q.A.HAMDI* AND H.A. AL-HILLI
Department of Physics, College of Science, University of Baghdad Jadirya - Baghdad – IRAQ. e.mail SKJaJani@uruklink.net
** Department of Basic Science, College of Agriculture University of Baghdad*

ABSTRACT

The a.c. conductivity $\sigma_{a.c}$ (ω) at angular frequency or radiation (ω) of binary TeO_2-MoO_3 glasses containing (0,10,20,30,40,50,55) wt% of MoO_3 , has been measured at temperatures (35-170) ^oC and at frequencies up to 10MHz . The result of σa.c (ω) and the density of states shows an increase with the increment of MoO_3 content. The results are interpreted in terms of a correlated barrier hopping (CBH) model.

INTRODUCTION

Tellurite glass systems are of technological interest because of their low melting points and the absence of the hygroscopic properties which tend to limit the applications of phosphate and borate glasses. They also have large refractive indices and are good infrared transmitters for wave lengths up to 5 μm. Molybdenum tellurite glasses of various compositions have been reported as semiconductors since 1990[1]. The general condition for semiconducting behaviour is that the transition metal ion (TMI) should be capable of existing in more than one valance state, so that conduction can take place by the transfer of electrons from low to high valance state.

An interpretation of the conduction process is difficult since the conductivity is affected by numerous factors including the nature and concentration of the (TMI), the concentration of TMIs In a reduced valence state , the preparation conditions , and the existence of microscopic or macroscopic structures within the glass matrix [2].

Amorphous semiconductors, generally exhibit a frequency dependent conductivity,

$$\sigma = A\omega^S \qquad \text{.....(1)}$$

in the frequency range covered by conventional bridge techniques [3].

Two fundamental models have been applied to explain the a.c. conductivity in amorphous materials. The quantum mechanical tunneling (QMT) model was first proposed by Pollak and Geballe [4] to interpret impurity conduction lit n-type silicon. In this model, the exponent (s) is temperature independent, and frequency dependent.

The correlated barrier hopping (CBH) model proposed by Elliot [5,6] has been applied to glassy semiconductors . In this model two electrons may hop over a potential barrier between defect sites and the expondent (s) is frequency independent, temperature dependent and its values are less than unity and decrease with increasing temperature.

In this model, electrons in the charged defect state hop over the coulomic barrier, whose height is given as W:

$$W = W_M - \frac{4ne^2}{\in R} \quad \text{.....(2)}$$

Where W_M is the maximum height of the energy band, $\in$ is an effective dielectric constant which may be taken as the bulk dielectric constant $\in$, e is the electronic charge , n is the number of electrons that hop [in the case of glasses , n=2] , and R is the distance between the hopping sites . The relaxation time τ for the electrons to hop over a barrier of height W is given by:

$$\tau = \tau_0 \exp(-W / KT) \quad \text{.....(3)}$$

where τ_0 is the order of an atomic vibrational period (~10^{-13} sec) and K is the Boltzman constant . The final expression for a.c conductivity is:

$$\sigma_{a.c} = \left[\frac{\pi^2 N^2 \in}{24} \left(\frac{8e^2}{\in W_M} \right)^6 \frac{S}{\tau_0^{\beta}} \right] \quad \text{.....(4)}$$

where N is the concentration of localized states and β is given by:

$$\beta = \frac{6KT}{W_M} \quad \text{.....(5)}$$

$$\beta = 1 - S \quad \text{.....(6)}$$

The analyses in the frameworks of the quantum mechanical tunneling and barrier hopping models do not satisfactorily explain the a.c conductivity data. Recently Long [7] has proposed a polaron tunneling model which applied to the frequency – dependent of the exponent (s) in amorphous germanium.

The objective of the present work is to explore the frequency and temperature dependence of a.c conductivity of the Tellurium – Molybdenum glasses in the range (10^2-10^7) Hz and in the temperature range (35-17O) °C. The-experimental results are interpreted in terms of existing theories of hopping conductivity.

EXPERIMENTAL

The glasses under study have been prepared by mixing analar TeO_2 and MoO_3 in specified proportion, using alumina crucibles . The mixture were heated in an electrical furnace for one hour at 400°C to prevent tendency to votalization . The crucible with mixture transferred to an electric furnace held at temperature of (800-850)°C depending on the ratio of MoO_3 for one hour . The melt was quenched in graphite mold, which was preheated to 300°C in air. The mold with the glass sample were transferred to another furnace for annealing at 300°C for 1 hour then switched off to cool down to room temperature. The

prepared glasses were examined by x-ray diffraction for distinguishing glassy states using anX-ray diffractometer.

For electrical measurements, disk – shaped samples of 25 mm in diameter and (3.0-3.12) mm in thickness where polished. The ohmic contacts, gold electrodes were deposited on both the surfaces of the disk shaped samples by vacuum evaporation. Electrical measurement were carried out in a precision RLC meter [Multi Frequency LCR meter 4274 A & 4275 A] for frequencies (f= ω/2) between (10^2-10^7)Hz . Measurement were made in the temperature range (35-175)°C.

RESULTS AND DISCUSSIONS

The experimental results of the a.c conductivity $\sigma_{a.c}(\omega)$ for the TeO_2(100-x) – MoO_3 (x) glassy system [where x=0,10.20,30,40,50,55]wt% were taken in the frequency range (10^2-10^7) Hz . The variation of $\sigma_{a.c}(\omega)$ with frequency is shown in Figure 1 for all concentrations of MoO_3 and at temperature 35°C . Figure 2 shows the variation of $\sigma_{a.c}$ (ω) at various temperatures. As is shown in Figures (1.2) the variation is in accordance with equation (1), where s is less than unity and its numerical values are in the range $0.9l > s > 0.88$ at room temperature [its values are shown in Table 1] . It has been established that a value of (s) close to unity is to be associated to lattice responses [8]. Figure 3 shows the frequency exponent (s) as a function of temperature. It seems that the exponent (s) decreases with increasing temperature.

Figure (4) shows the dependence of $\sigma_{a.c}$ (ω) as a function of MoO_3 concentrations at different temperature and a certain frequency. From these curves, it is obvious that the a.c conductivity increase as a result of MoO_3 addition for different temperatures almost in the same modes.

In addition, the a.c conductivity is increased with temperature and this could be due to the thermal activation energy which helps the electrons to hop over the barriers or to transport between band or defect states.

The data of the exponent (s) presented in Table I, dependent on temperature and independent of frequency and it seems that the most convenient model for a.c conduction in TeO_2-MoO_3 glasses is the CBH model.

Therefore according to this model we can calculate the density of states using equations (4-6) at temperature 35°C and 1KHz frequency. Figure 5 shows the variation of density of states N with MoO_3 concentrations [details in Table 2] . From this figure, it is clear that the density of localized states increases as a result of MoO_3 addition.

From previous details we can clarify the increment in $\sigma_{a.c}(\omega)$ conductivity as a function of MoO_3 content as follow:

First by adding MoO_3 to the tetrahedral unit cell TeO_4 of the structure will attacked by Mo atoms and replaced Te atoms which is the cause of non bridging oxygens . So a deep donor level may a rise above the valance band which is shifted toward the conduction band and contribute to some hopping conduction as MoO_3 concentration increases.

Secondly , the increasing of MoO_3 ratio will increase the disordering in the structure and enhancing the conduction band tail . Our results are in a good agreement with other glass

systems [9, 10]
We conclude from above discussion that the a.c electrical conductivity is influenced by concentration of Mo ions and the most proper model to describe the a.c conductivity for our glass systems is the correlated barrier hopping (CBH) model.

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