

Study Of Metal-Water Interface Formed By Zn Electrodes

Dr. Anurag Saxena

Associate Professor, Department of Physics, D.A-V. College, C.S.J.M. University, Kanpur

Abstract – The metal-water interface formed by Zn-electrodes placed in water is studied by the measurement of potential difference as a function of transducer voltage for different pulse parameters and inverse pulse duty ratio is reported. The present work is important as it provides fruitful information about the electrical double layer.

Index Terms – Transducer Voltage, Inverse Pulse Duty Ratio, Irradiation Time.

I. INTRODUCTION

Cavitation [1-7] refers to bubbles or voids usually occurs in response to a reduction of the pressure sufficiently below the vapour pressure of the liquid or to the elevation of the temperature above the boiling point, although chemical, electrical and radiation induced phenomenon can be important. Cavitation tests are one way of characterizing the liquid medium. Cavitation events in a liquid can also be a measure of ionizing radiation incident on the samples, thereby providing a way of learning about radiation matter interaction. The two basic types of acoustically induced cavities are (1) stable cavity, which oscillates many times about its equilibrium radius and (ii) a transient cavity which undergoes much greater variations from its equilibrium size in relatively few acoustic cycles and which may terminate in a fairly violent collapse (the interface velocity can approach or exceed the speed of sound in liquid). The purpose of this paper is to see the effect of high intensity pulsed ultrasonic field on the electrical double layer created when metal Zn is placed in water. The difference in potential between two metal electrodes one in the focal zone and other out of focal zone of the transducers has been measured for different irradiation time (trr) using an experimental setup described elsewhere [3].

II. EXPERIMENTAL DETAILS

When the metal is placed in water, there is an electrified interface consisting of water molecules, dissolved oxygen molecules and hydrogen ions. Hence the interface under consideration may be that between an electronic conductor and an ionic conductor. The water molecules which are electrical dipoles may form an oriented layer on the metal surface. Such an oriented dipole layer is equivalent to two sheets of charge. There is an exchange of electrons between metal and hydrogen ions. As a result of the two sides of the

interface between metal and water are charged and a potential difference is developed across the interface.

The metal of about 99% purity was procured from Division Chemical Industries Milano Italy. The pulsed technique available [1,6] in the laboratory has been used. The reasons of choosing the pulse method for the measurement are its advantages namely (i) It allows a larger number of measurement at equal cavitation damage by the degassing effect of the liquid sample (ii) The time development of the cavitation process can be examined (iii) The hydrodynamic flow and the effective transducer radiation resistance which are factors influencing the development of cavitation can be better controlled by a proper choice of pulse times (τ) and inverse pulse duty ratio ($N=v\tau$)⁻¹, v = repetition frequency in the case of pulsed ultrasonic radiation (iv) It is possible to optimize the efficiency of peculiar cavitation effect. Intrinsic to the cavitation process are its large spatial and time intensity foundation of the bubble implosions and to the sonic energy drain by formation and destruction of the bubbles due to acoustic cavitation.

The technical details of the apparatus are widely described elsewhere [3,6]. The pulses of given time and inverse duty ratio are obtained from the pulse generator. These pulses modulate radio frequency as desired, which after a power amplification derives the corresponding transducer. The ultrasonic cell is cylindrical and has six windows. Four of them used for applying Piezoceramic converging transducers and hydrophones. The hydrophones are used for the relative calibration of the ultrasonic fields of different frequencies. The fifth window is used for inserting the metal electrodes. The sixth window is closed for some other purposes.

The working electrodes were made of the metal with a free surface of about 4 mm² in the form of the wire. The potential difference was measured by using a digital meter ($R = 10M\Omega$). The ultrasonic field of 0.7 MHz was produced by a Piezoceramic transducer having a focal zone 10 cm. from its surface. The position of the first electrode was near the focal zone. The other electrode of the same metal was placed out of the focal zone to reduce the effect of the same field on this electrode. The measurements were carried out in distilled water for different transducer voltages (V), pulse parameters (N, τ) and irradiation time (trr). The recovery time (tr) to achieve initial value of difference in potential when irradiation stopped was also measured.

III. RESULTS AND DISCUSSIONS

Fig.1 (a, b, c) show the variation of potential difference $\Delta\phi$ (in mv) with transducer voltage V (in volt) for same pulse repetition period $T = 150$ ms of Zn-Zn probes. In fig. 1(a) inverse pulse duty ratio is $N = 2$ Irradiation time t_{rr} for curves (i) and (ii) in figure 1 (a, b, c) 10s and 20s respectively.

In Fig. 1(a) potential difference $\Delta\phi$ is 42mv at transducer voltage (T.V.) 7 volt. It decrease to minimum 20 mv at T.V. 40 volt then it again increases upto T.V. 75 volt for $t_{rr} = 10$ s. For irradiation time 20s in curve (ii) $\Delta\phi$ is almost constant upto T.V. 40 V then it increases upto T.V. 80 volt.

In Fig. 1 [b] inverse pulse duty ratio $N=10$ for irradiation time $t_{rr} = 10$ s in curve (i) increase upto T.V. 40 volt then it decreases upto T.V. 60 volt. Thereafter $\Delta\phi$ again increases and attains a maximum value 120mv at T.V. 70 volt after that it decreases upto T.V. 90 volt. In curve (ii) for irradiation time $t_{rr}=20$ s $\Delta\phi$ initially decreases upto T.V. 40 volt then increases and becomes maximum at T.V. 70 volt after that it decreases.

In Fig 1(c) inverse pulse duty ratio $N=100$. The constant and equal behaviour is found for $N=100$ irrespective of irradiation time.

IV. CONCLUSION

The potential difference measured as a function of transducer voltage explains different stages of cavitation.

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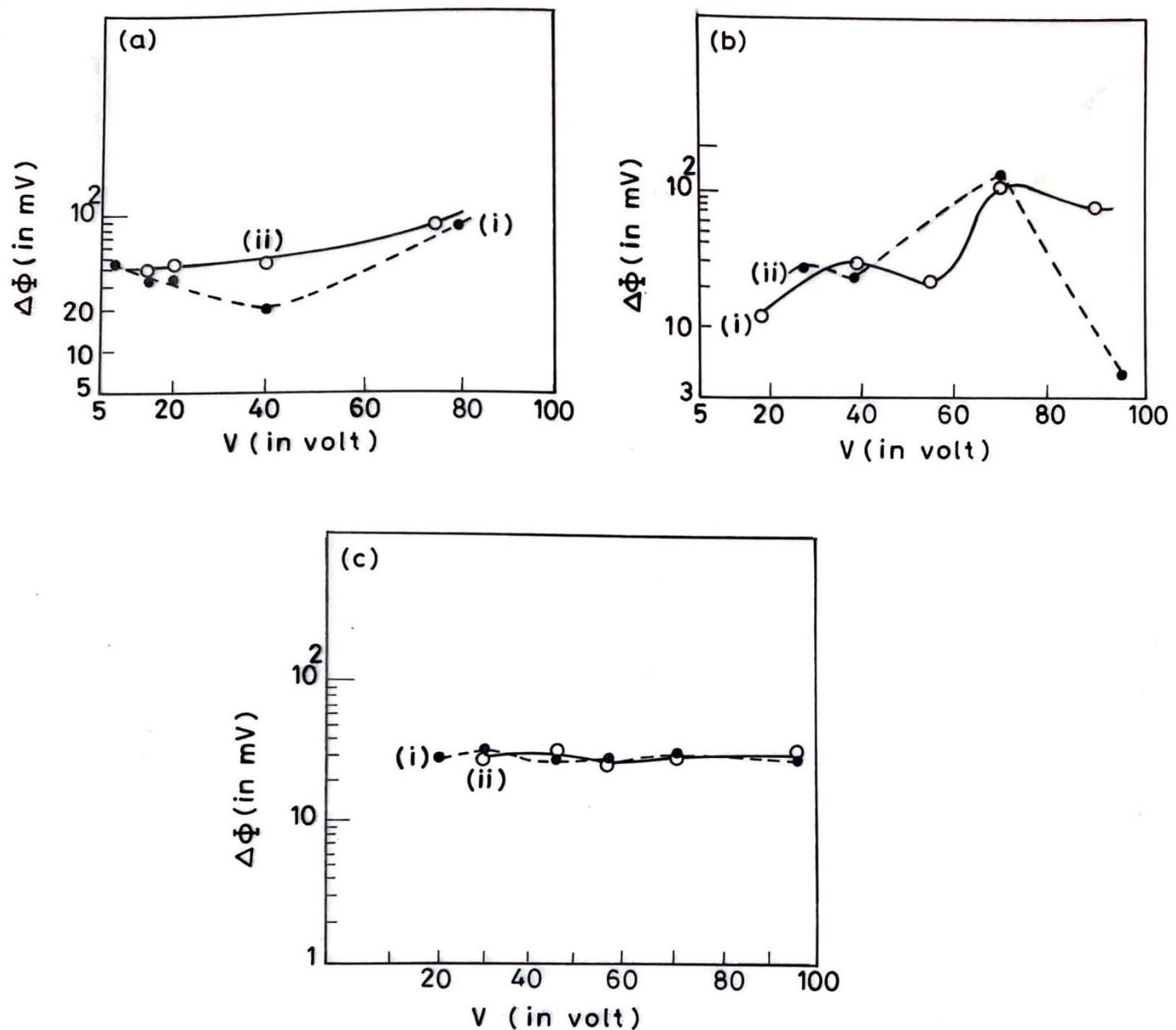


Fig.1 Variation of potential difference $\Delta\Phi$ (in mV) Vs. transducer voltage V (in volt) for same pulse repetition period $T=150$ ms and irradiation time t_{rr} (i) 10 s and (ii) 20 s
(a) $N=2$; (b) $N=10$; (c), $N=100$