Effect of mercury rate on the ultrasonic and mechanical properties of dental amalgam

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Abstract

The objective of this study was to evaluate the effect of mercury rate on the ultrasonic and mechanical properties of dental amalgam by ultrasonic technique. Non gamma2 amalgam samples were prepared by mixing a standard amount of amalgam powder with different amounts of mercury 50, 35, and 20% for 35 seconds. The samples have been examined after being hardened. Ultrasound longitudinal velocity and ultrasonic attenuation coefficient were measured. Then mechanical properties have been calculated. The results showed the influence of mercury rate on amalgam properties. Mechanical properties decrease with increasing the mercury rate.

Keywords: *Dental amalgam; Mechanical properties; Mercury; Ultrasonic*.

1. Introduction

Mercury is a polyvalent metallic element being liquid at room temperature which represents thermoelectric power and various other peculiar properties [1]. Mercury can dissolve nearly all metals, forming liquid or solid solutions known as amalgams. One of the well-admired compounds of this element is the dental amalgam, which has been found useful over the last 150 years for dental filling. The dental amalgam is a combination of mercury with a specially prepared silver alloy, which is used as a restorative material. Silver, copper and mercury are the amalgam constituents, where silver is the main component and mercury usually forms more than 50% (w/w%) [2], [3], [4], and [5].

In spite of the potential toxicity of mercury from mercury amalgam, silver amalgam is popularly used as a direct restorative filler material available due to its high strength, durability, and low cost as well as long-term satisfactory clinical performance [6], [7]

A number of researches have aimed determining properties of mercury amalgams such as phase diagrams and thermodynamic properties for Ag–Hg and Cu–Hg binary systems [8] and [9].

The aim of this study was to evaluate the effect of mercury rate on the ultrasonic and mechanical properties of non-gamma 2 amalgam by the method of ultrasound,

2. Materials and methods

The non-gamma 2 amalgam with different concentrations of mercury 50%, 35% and 20%) was used in this study. After mixing time, the specimens were placed in the molds, after the completion of hardening; the hardened samples were removed from the molds and used in the investigation.

Figure 1 show the experimental setup of the transmission method. The experimental design for this study is composed primarily of two same ultrasonic transducers plans for center frequency 5MHz for each one. The first transducer is a transmitter excited in pulsed mode with a pulse generator Sofranel Model 5052PR. Sensor response following to this excitation is reflected by the generation of ultrasonic waves which propagate in the first coupling medium (in our case: water) then they cross the steel specimen. They will be captured after they pass through a second coupling medium (here: water) by the second transducer that plays a role of the receiver. The latter returns the ultrasound signal picked up towards the generator to amplify, and then the amplified ultrasonic signal will be sent to the oscilloscope HP54600B to visualize it. After averaging operation to improve the signal/noise ratio signal visualized, it will be forwarded to the computer through the port via GPIB IEEE National data acquisition card Instrument controlled by the LabView software. We have developed a platform with Labview which allows us to easily manipulate the signals acquired their registration and calculation of the FFT automatically for each signal.

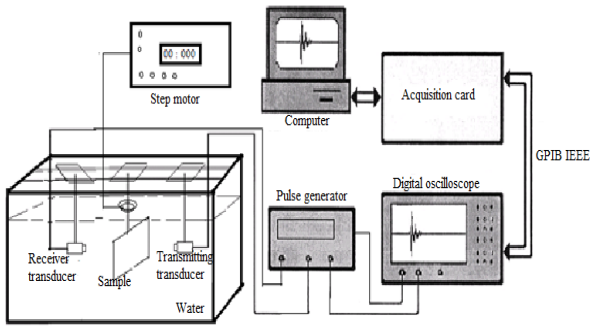

Figure.1: Diagram of the experimental device.

For measuring the velocity o ultrasonic waves in amalgam samples, we measure the flight time required for the wave to propagate the thickness thereof from which the ultrasonic signal that through by the sample. Thus the speed is calculated using the following formula:

$$V = \frac{d}{t_v}$$

With d is the thickness of the amalgam plate and t_v is the flight time

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3. Results and discussions

The Figures.2, 3 and 4 show the amplitude of the transmitted signal as a function of time, their Fourier transform, the spectral amplitude for each echo and evolution of the attenuation coefficient depending on the frequency for the amalgam with 50%, 35% and 20% of mercury respectively.

Table.1 presents the ultrasonic, mechanical properties and attenuation coefficient of the amalgam with 50%, 35% and 20% of mercury.

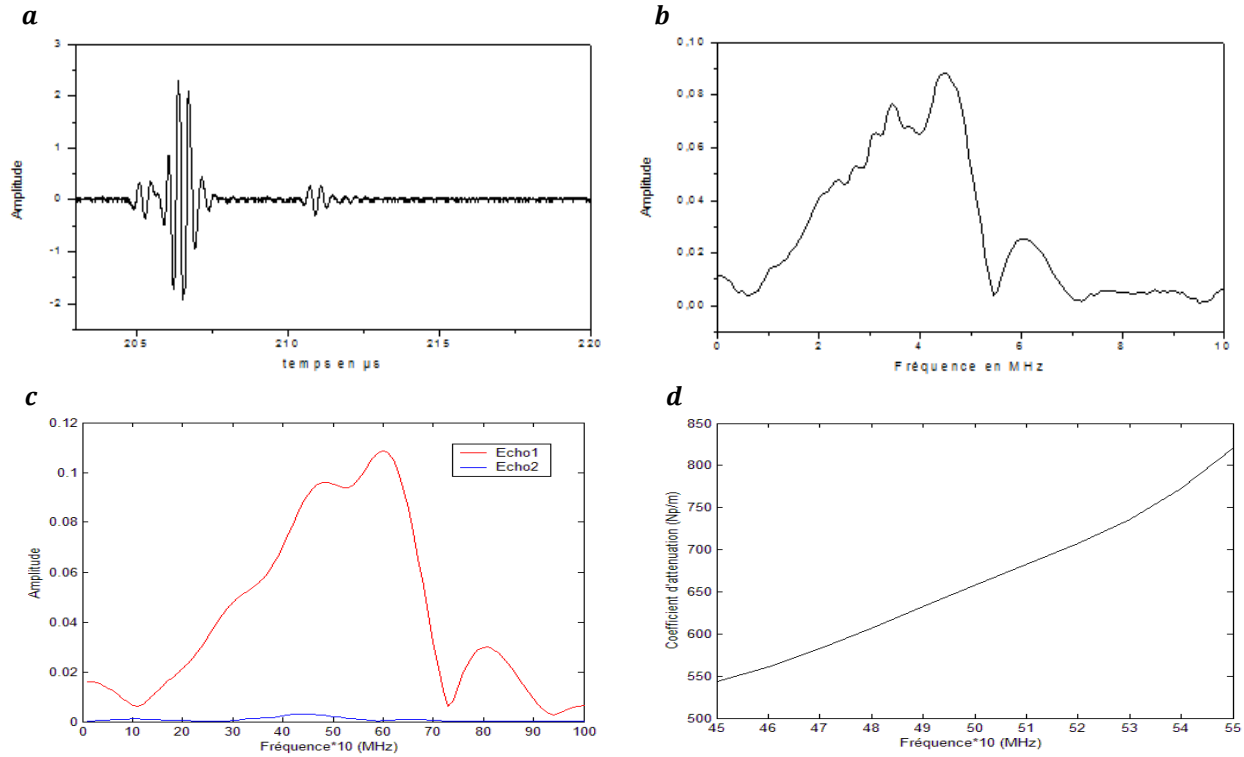

Figure.2: Transmitted signal (a), Fourier transform (b), the spectral amplitude (c) and attenuation coefficient (d) of the amalgam with 50% mercury rate

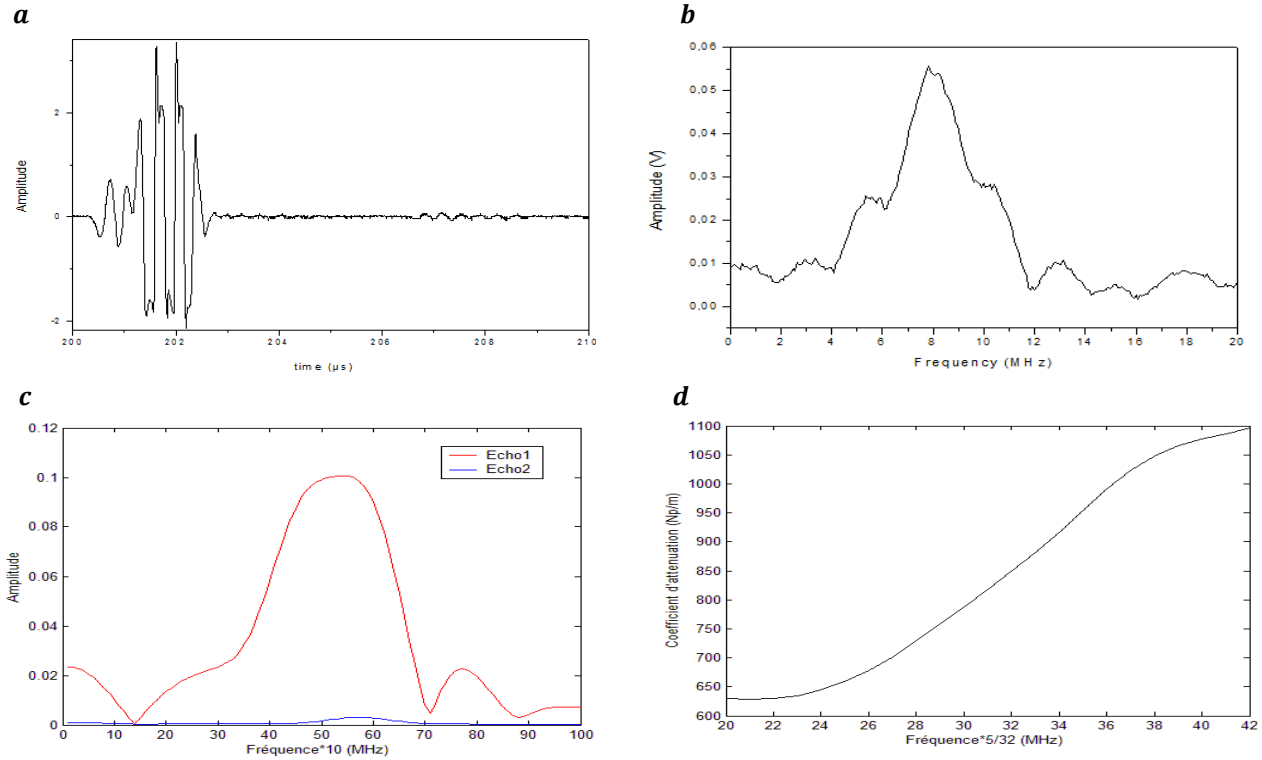

Figure.3: Transmitted signal (a), Fourier transform (b), the spectral amplitude (c) and attenuation coefficient (d) of the amalgam with 35% mercury rate.

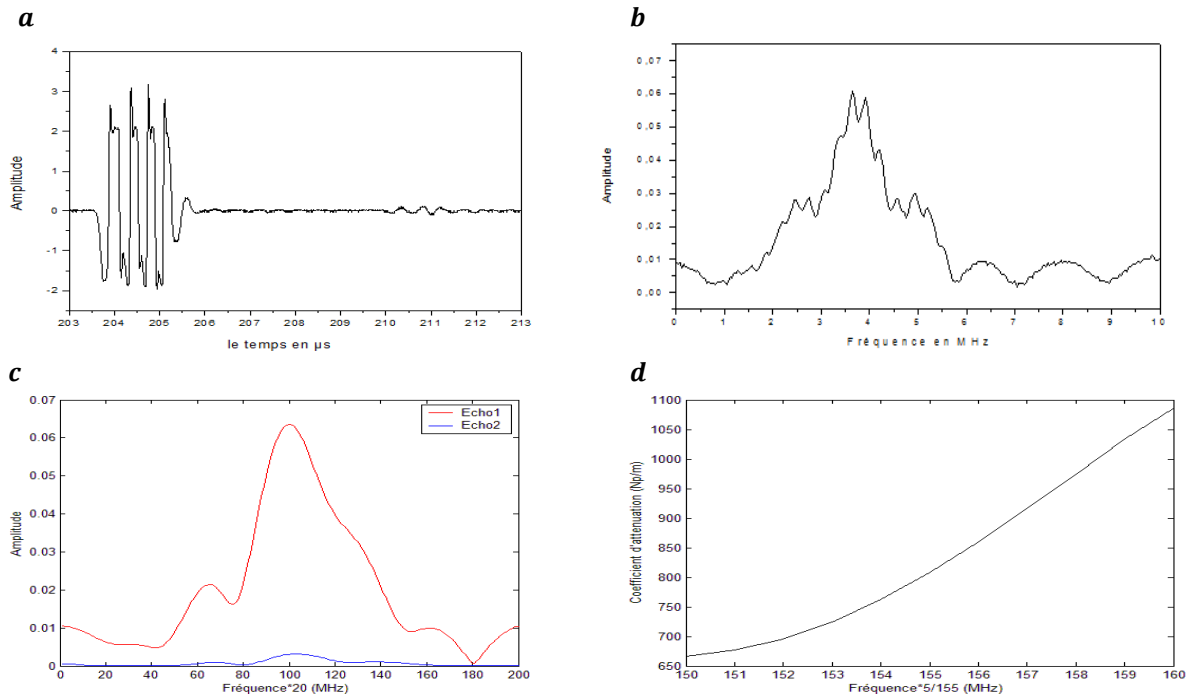

Figure.4: Transmitted signal (a), Fourier transform (b), the spectral amplitude (c) and attenuation coefficient (d) of the amalgam with 20% mercury

Table.1 Ultrasonic and mechanical properties of amalgam with different mercury rate.

The amount of mercury in amalgam (%)	50	35	20
Thickness (mm)	1,3	1.8	2,1
Density(g/cm^3)	12,42	12,07	11,72
The flight time (µs)	2.94	3,18	3,3
Longitudinal velocity (m/s)	884,27	1132	1272,72
The acoustic impedance (Kg/(s.m^2))*10^6	10,982633	13,663240	14,916278
Young's Modulos (Mpa)	6.47	10.31	11.65
Attenuation coefficient in the frequency range [4MHz ;6MHz]	650	750	800

From these results, it is found that the ultrasonic and mechanical properties of the amalgam depend strongly on the mercury rate. The measured results show the decrease of these characteristics with increasing the mercury rate in the samples.

4. Conclusion

The objective of this study was to investigate the effect of mercury rate on the ultrasonic and mechanical properties of dental amalgam. Ultrasonic parameters, namely longitudinal velocity and attenuation coefficient, were measured, using transmission ultrasonic method. Mechanical properties were measured. The ultrasonic and mechanical properties of amalgam decrease with increasing the mercury rate.

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