

Silicone plastination of a whole dissected body

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Abstract

Plastination is a technique developed by Von Hagens in the year 1979. In this technique water and lipids present inside the tissue are replaced by a curable polymer, resulting in a dry odorless specimen that can be kept without any change for years together. Water and lipids present in the tissues cannot, however, be replaced directly with the polymer, because the two are chemically incompatible. So initially the water and lipids are replaced by a dehydrating agent like acetone and this dehydrating agent is subsequently replaced by the curable polymer by applying vacuum. The polymer is subsequently hardened, resulting in a dry, odorless specimen. Whole body silicone plastination is done in many institutions of Anatomy in foreign countries. In India plastination of whole dissected bodies using silicone polymer is not practiced until now. In our present study we have plastinated a whole dissected body using a commercially available two component silicone polymer (figure-1) called TSE3455T (A) and a curing agent TSE3455T (B), resulting in a dry odorless dissected whole body specimen, which can be kept in the museum for ready demonstration of the various structures to the medical and paramedical students.

Key words: Acetone, Dehydration, Forced impregnation, Polymer, Curing

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Introduction

Initially Whole body plastination was done only by Gunther Von Hagens for exhibiting dissected plastinated bodies in his body worlds. Body worlds is a museum developed by Von Hagens for exhibiting human bodies and organs. Body Worlds was first presented in Tokyo in 1995. According to the procedures developed by Von Hagens, whole dissected bodies must be plastinated only by silicone polymers. He stated that plastination with silicone polymer (S10) alone can give an opaque, flexible and natural looking specimen [1]. Silicone plastination of whole body is not widely practiced mainly because of the cost of the polymer and further the exact composition of the silicone polymer was not revealed in any of the previous studies. In the original protocols for whole body silicone plastination, the polymer is simply named as Biodur S10 polymer and its curing agent as S3. The standard Biodur silicone S10 polymer can be kept for a very long time at room temperature but following mixing with its curing agent S3, it must be used and stored in a deep freezer. So with S10.

Polymer the whole process of plastination can be done only at very low temperatures inside a deep freezer [2]. Later with the help of spectrometric studies the main component present in the Biodur S10 product was found to be polydimethylsiloxane (figure-1). With the help of this finding similar products and processes have been developed. The North Carolina room temperature-plastination process is a modification of the Biodur S10 plastination process. In this process an additional chain extender (NCSV) is used [3]. The Nanjing plastination factory in China (started in 1995) developed a new silicone polymer called Su Yi Chinese silicone [4], which even after mixing with the curing agent can be stored at room temperature for a prolonged period and with this polymer, plastination can be done at room temperature without the need of an explosion proof deep freezer. A similar Dow room temperature silicone plastination technique was developed in USA in 2007 [5].

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At present there are two types of silicone plastinations, one is the low temperature silicone plastination developed originally by Von Hagens in which both dehydration and forced impregnation by vacuum are done at low temperatures inside an explosion proof deep freezer [6] and the other is the room temperature silicone plastination where both dehydration and forced impregnation by vacuum are done at room temperature [7],

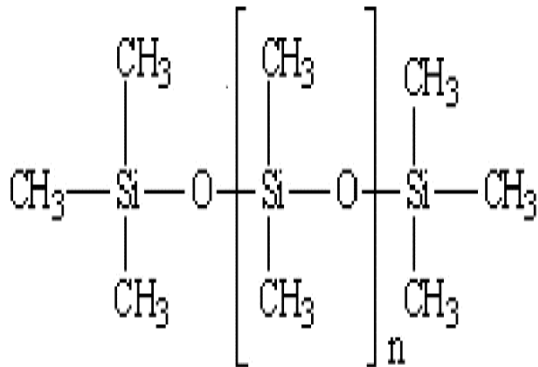


Figure-1: Structural formula of polydimethylsiloxane



Figure-2: Silicone polymer TSE3455T (A) & (B)

In our present study in order to produce a high quality, naturally looking specimen at low cost, we have done room temperature silicone plastination of an unclaimed body allotted for dissection to the I MBBS students,. The body was plastinated using a commercially available silicone polymer TSE3455T purchased from Momentive Performance Materials Inc (figure-2). We have not plastinated any donated bodies mainly to prevent ethical issues. During the process of plastination, the formalin fixed dissected body was dehydrated in a graded series of acetone at room temperature. The volume of acetone used for dehydration must be about 5 times the weight of the body. A direct reading acetonometer was used to measure the acetone concentration [8]. After dehydration the body was transferred to a large steel container containing the silicone polymer (TSE3455T -A) mixed with a curing agent (TSE3455T -B). Both when mixed in the ratio of 100:10, will cure within 48 to 96 hours. But in the present study the Polymer and hardener were mixed in the ratio of 100:1, to prevent quicker curing. At this ratio the TSE3455T polymer can be stored and used at room temperature for more than a week. The dehydrated body immersed in the silicone polymer and hardener mixture was kept at room temperature for a period of 24 hours. During this period the surface solvent (acetone) and the polymer reaction mixture will equilibrate with each other and some amount of exchange between the silicone and the acetone can take place at this stage even without vacuum, which can reduce the duration for forced impregnation [9]. After a period of 24 hours the body immersed in the silicone bath was placed inside a vacuum chamber and vacuum was applied at room temperature. Reducing the pressure inside the vacuum chamber by applying vacuum causes the acetone to boil and vaporize. Once the acetone vaporizes and escapes out of the tissues, an empty space is created inside the tissues. This empty space is later permeated by the Silicone polymer. This process of applying vacuum and forcing the polymer to permeate the tissues is called forced impregnation [10].

Aim of the study:

To produce a high quality dissected dry, formalin free plastinated whole body specimen, for demonstration to the medical students.

Methods and Materials

Silicone plastination includes the following procedures, fixation, dehydration, vacuum application and curing.

Fixation. The body was fixed with a solution of 10% formal saline. The period for fixation was about 48 hours.

Dehydration-The body fixed by formalin was dissected. Dissection was done meticulously to show the superficial structures of the body, like muscles, nerves and blood vessels. The internal organs were not displayed by opening the body cavities. The thoracic wall, anterior abdominal wall and the skull were kept intact. The dissected body is then transferred to a tank containing acetone. Dehydration by acetone was done at room temperature. Three changes of acetone, 50%, 70% and 100% were made. Each change was made at an interval of one week (one week for each change).

The total period for dehydration was about three weeks. The acetone concentration was measured using an acetometer. Dehydration was considered to be complete when the acetone concentration was stable for a period of last three consecutive days.

Vacuum application- After complete dehydration, the body was immersed in a mixture of silicone polymer and curing agent mixed in the ratio of 100:1 in a steel container and kept at room temperature for a period of 24 hours. At the end of 24 hours the specimen immersed in the polymer bath was placed inside a vacuum chamber and the chamber was connected to a vacuum pump. The vacuum chamber was designed locally to reduce the cost (figure-3). Vacuum was applied slowly starting from morning and completed in the evening (when a pressure of -20 mmHg was obtained). This process of applying vacuum from morning to evening was repeated for a period of one week.



Figure-3: Vacuum chamber

Curing-At the end of the week the body was taken out of the silicone polymer and placed under sunlight to initiate curing. Curing under sunlight was done for a week.

Discussion

Dehydration at -25°C and force impregnation by supplying vacuum at low temperature (-10°C) are the original protocols for silicone plastination. Dehydration at -25°C will prevent shrinkage of tissues [11]. Similarly forced impregnation by vacuum must also be done at low temperatures inside an explosion proof deep freezer, to avoid quicker hardening of the polymer and curing agent mixture [12]. Both dehydration and forced impregnation by vacuum can also be done at room temperature. This technique is called as room temperature plastination. Room temperature plastination was originally developed in china with the use of Su Yi Chinese silicone polymer developed in 1995 and later in USA in the year 2007. In all types of silicone plastinations after impregnation by vacuum, curing must be done by exposing the body to a gas inside a closed glass chamber. But in the present study to reduce the cost, curing was done simply by exposing the body to sunlight.



Figure-4: Plastinated whole dissected body

In our present study, both dehydration and forced impregnation by vacuum were done at room temperature. Dehydration was done in a graded series of acetone. Dehydrating the specimen in a graded series of acetone will prevent shrinkage of specimens [13]. Forced impregnation by vacuum was also done at room temperature with the help of a locally designed vacuum chamber. The commercially purchased TSE3455T (A) when mixed with the curing agent TSE3455T (B) in the ratio of 100:10 (ratio given in the product manual), will cure within 48 to 96 hours, making the necessity for forced impregnation by vacuum at low very temperature (at low temperatures, the reaction between the polymer and curing agent mixture is prolonged). Quicker hardening of the TSE3455T silicone polymer was prevented by reducing the quantity of the curing agent (in the ratio of 100: 1). By reducing the quantity of curing agent, vacuum can be applied at room temperature for a period of more than a week. Reducing the quantity of curing agent also results in the production of more flexible specimens [14]. The silicone polymer TSE3455T (polydimethylsiloxane) used in our study is commercially available and its cost is much lower than that of the original S10 polymer supplied by the Biodur Company (German company owned by Von Hagens). The high quality specimens produced by this silicone plastination can be used as dry specimens for demonstration to the students for years together. This will reduce the need for new cadavers and specimens [15-18].

Result

A high quality dry and odorless plastinated dissected whole body was produced. This plastinated body can be kept as a dry specimen for any number of years (figure-4).

Conclusion

The unclaimed body allotted to the first MBBS students was plastinated on June 2015 (figure-4). The shrinkage of the body after plastination was only about 5%. Till now structures like muscles and blood vessels were well preserved without any marked change in size shape and. Color (figure-4). Since a cadaver is as precious as gold to an Anatomist, calculating the total duration for dehydration and vacuum application must be done carefully. Any mistake in the above two procedures will spoil the whole technique resulting in a low quality specimen. The body must be completely dehydrated and during forced impregnation the pressure inside the vacuum chamber must be reduced slowly. Reducing the pressure quickly can result in improper permeation of tissues by the polymer, resulting in a compressed specimen [19]. Dehydration and forced impregnation by vacuum at room temperature have reduced the need for buying an explosion proof deep freezer [20] [21]. The use of a locally designed vacuum chamber and use of a commercially available silicone polymer have further reduced the cost of this technique. Finally curing was also done simply by exposing to sunlight. We have already plastinated a whole dissected body with polyester resin, which was much cheaper than the present study. But the quality of the specimen obtained (in the form of color and texture) in the present study using silicone polymer was excellent and no much changes were observed in the body after plastination. Using this technique high quality dry, odorless, toxic

free dissected whole body as well as individual organs and specimens can be produced, that can be used both for routine demonstrations as well as for mounting in the museum for years together without the toxic effects of formalin.

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