Influence of Dopamine Cross linking with Carboxy Methyl Cellulose Bone Adhesive

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Abstract

Introduction:Carboxymethyl cellulose is a derivative of cellulose with carboxymethyl groups which is attached to the hydroxyl group of glucopyranose monomers which forms the cellulose backbone.Dopamine is a type of neurotransmitter and hormone. The present study aims to find the influence of dopamine cross linking with carboxymethyl cellulose bone adhesive. Preparation of PBS solution and then solution separation followed by sending the sample for FT-IR spectroscopy, tensile strength test, SEM test and swelling test. Dopamine cross linked carboxymethyl cellulose is synthesized and confirmed FT IR spectrometry.The tensile strength is effective when CMC is cross linked with dopamine. This study concludes that when dopamine is cross linked with CMC it has a better adhesive property.

Keywords: Carboxymethyl cellulose, dopamine,bone adhesive

Introduction

Carboxymethyl cellulose is a derivative of cellulose with carboxymethyl groups which is attached to the hydroxyl group of glucopyranose monomers which forms the cellulose backbone. It is available in forms of sodium salt and sodium carboxymethyl cellulose.Carboxymethyl cellulose is prepared by reaction of monochloroacetic acid with alkali cellulose [1].

Then alkalisation of cellulose and etherification of alkali cellulose with MCA is done in presence of organic solvents.[2]Carboxymethyl cellulose is used in construction industry , detergents, plastics, medicine, paper industry, adhesives and paint. Because of its good biocompatibility,low toxicity, low immunogenicity and biodegradability,CMC has been widely applied in the field of tissue engi-neering [3] .

Dopamine is an endogenous catecholamine which acts as both neurotransmitter and precursor of norepinephrine synthesis.Dopamine regulates cardiac, vascular and endocrine function.Dopamine is synthesized from tyrosine in the nerve terminal which is transported across the blood brain barrier. [4]Dopamine can be used as adhesives as dopamine adsorbs on almost all kinds of surfaces by forming strong coordination bonds and develops cohesive strength through self-polymerization.

One of the unmet clinical needs of orthopedic trauma surgeons is a ‘‘bone glue’’ or an adhesive to fix a broken bone instead of the conventional metal plates, nails, pins, and screws. [5,6]Simplicity, quickness, and preservation of joint function, especially when fixing fractures with many small fragments, are the main benefits of a bone adhesive.[7] An additional benefit is elimination of metal removal from fractures fixed solely with a biodegradable adhesive.[5]

In recent years, dopamine has been widely used for the preparation of bio-adhesives primarily inspired by the superior adhesion of mussels in the ocean. Dopamine is used in carcinogenic shock, septic shock,pulmonary oedema and to prevent acute renal failure. Dopamine has many adverse effects like Tachyarrhythmia, limb necrosis, allergic reactions , hyperglycaemia and

ventricular fibrillation.The aim of this study to find the influence of dopamine cross linking with carboxymethyl cellulose bone adhesive [8]

Materials and Methods

Preparation of PBS solution: PBS (phosphate buffered solution) cm be prepared by mixing 90 ml of distilled water with 10 ml of PBS in a conical flask. 1 gram of carboxymethyl cellulose is added to the prepared solution.

Solution separation : The prepared solution was separated into two halves. 50 ml of controlled solution is kept aside and 50 ml of rest of the solution is added with 115mg of NHS, 180 mg of EDC and 350 mg of Dopamine which is covered with foil to avoid light and kept aside.

6 ml of PBS solution with dopamine was taken and mixed with 2ml HA solution each separately. It was kept for drying for 24 hours. After 24 hours when observed the solution had formed a dry strip. Samples were taken from the strip and sent for FT-IR spectroscopy, tensile strength test, SEM test and swelling test.

FT IR spectroscopy :The sample is placed in a holder in the path of the IR source. A detector reads the analog signal and converts the signal to a spectrum. A computer is used to analyze the

signals and identify the peaks. An IR beam goes through a partially silvered mirror, which splits the beam into two beams of equal intensity.

Tensile strength test :The idea of a tensile test is to keep a sample of a material in between two fixtures named "grips" which clamp the material. The material has known dimensions, like length and cross-sectional area. Then we start to apply weight to the material gripped at one end while the other end is fixed.

SEM test :SEM is the detection of high energy electrons emitted from the surface of a sample after being exposed to a highly focused beam of electrons from an electron gun. This beam of electrons is focussed to a small spot on the sample surface, using the SEM objective lens.

Results and discussion:

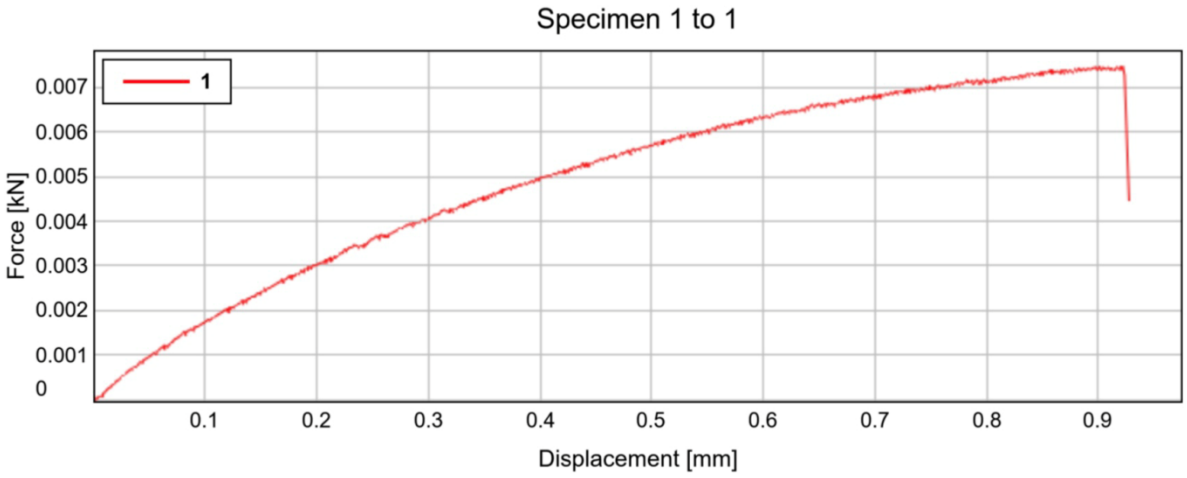
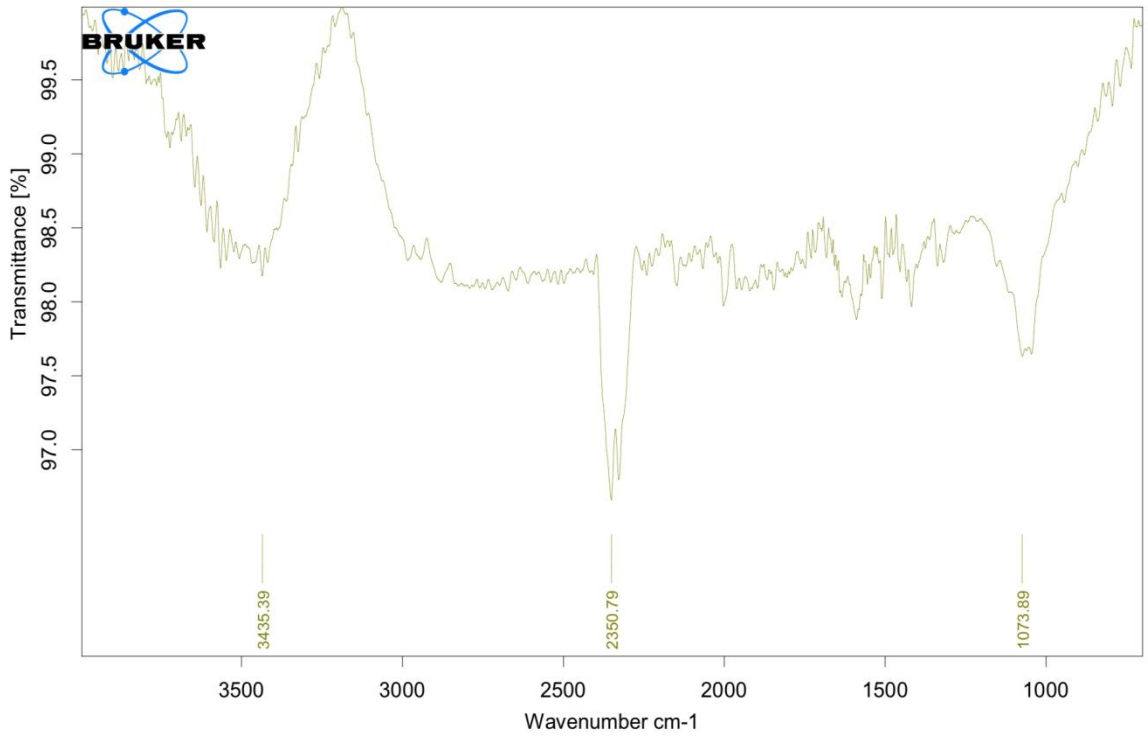


Figure 1 : Tensile test

The idea of a tensile test is to keep a sample of a material in between two fixtures named "grips" which clamp the material. The material has known dimensions, like length and cross-sectional area. Then we start to apply weight to the material gripped at one end while the other end is fixed.The tensile strength is effective when CMC is cross linked with dopamine.



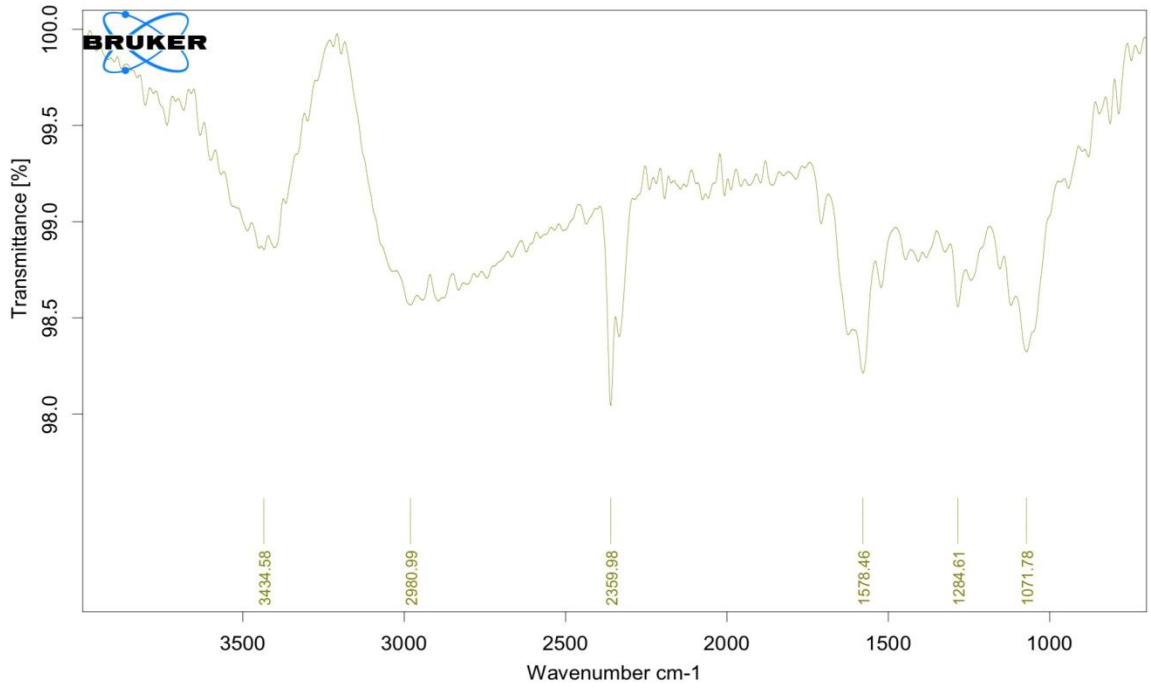


Figure 2 : FTIR Spectrometry

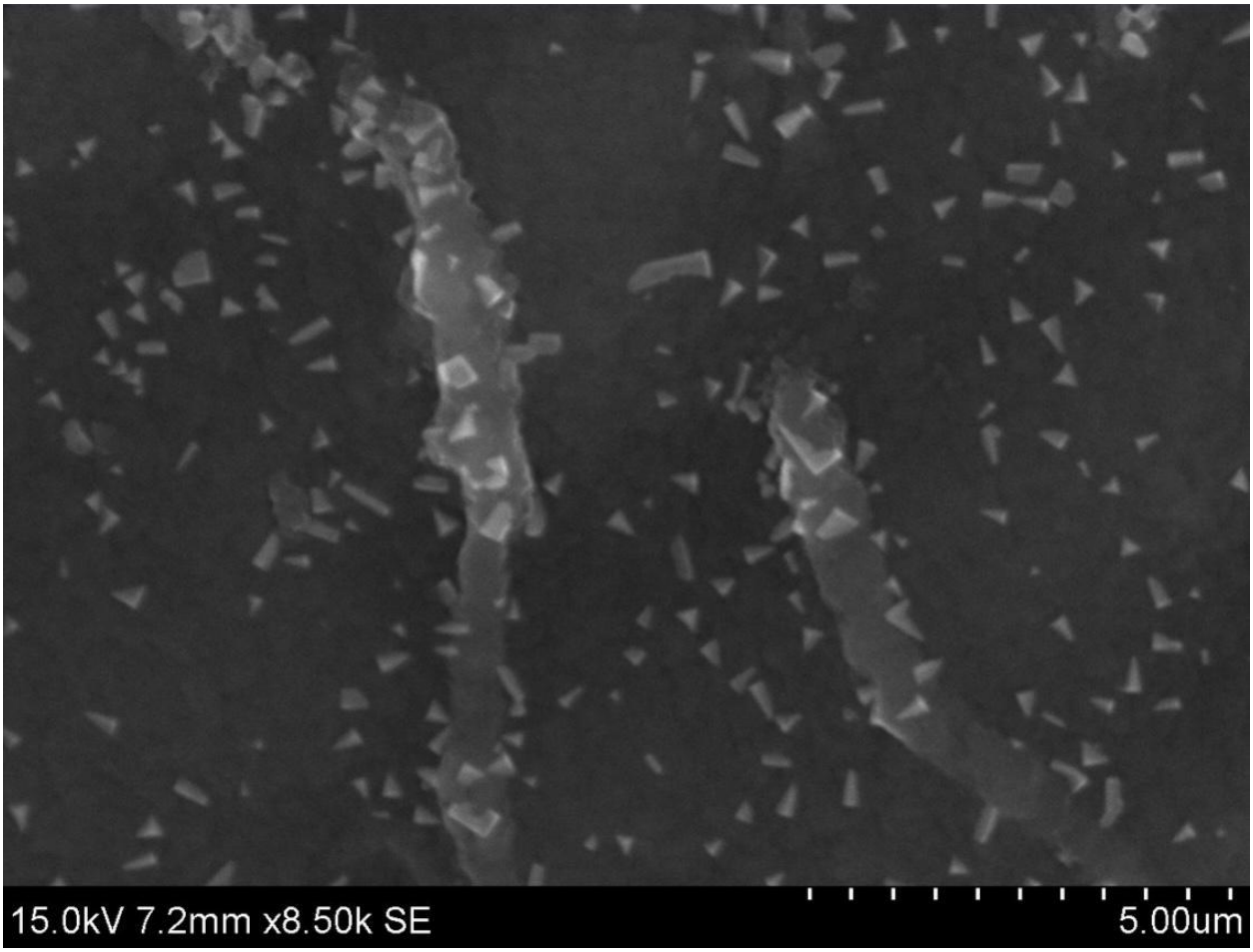


Figure 3a : SEM TEST

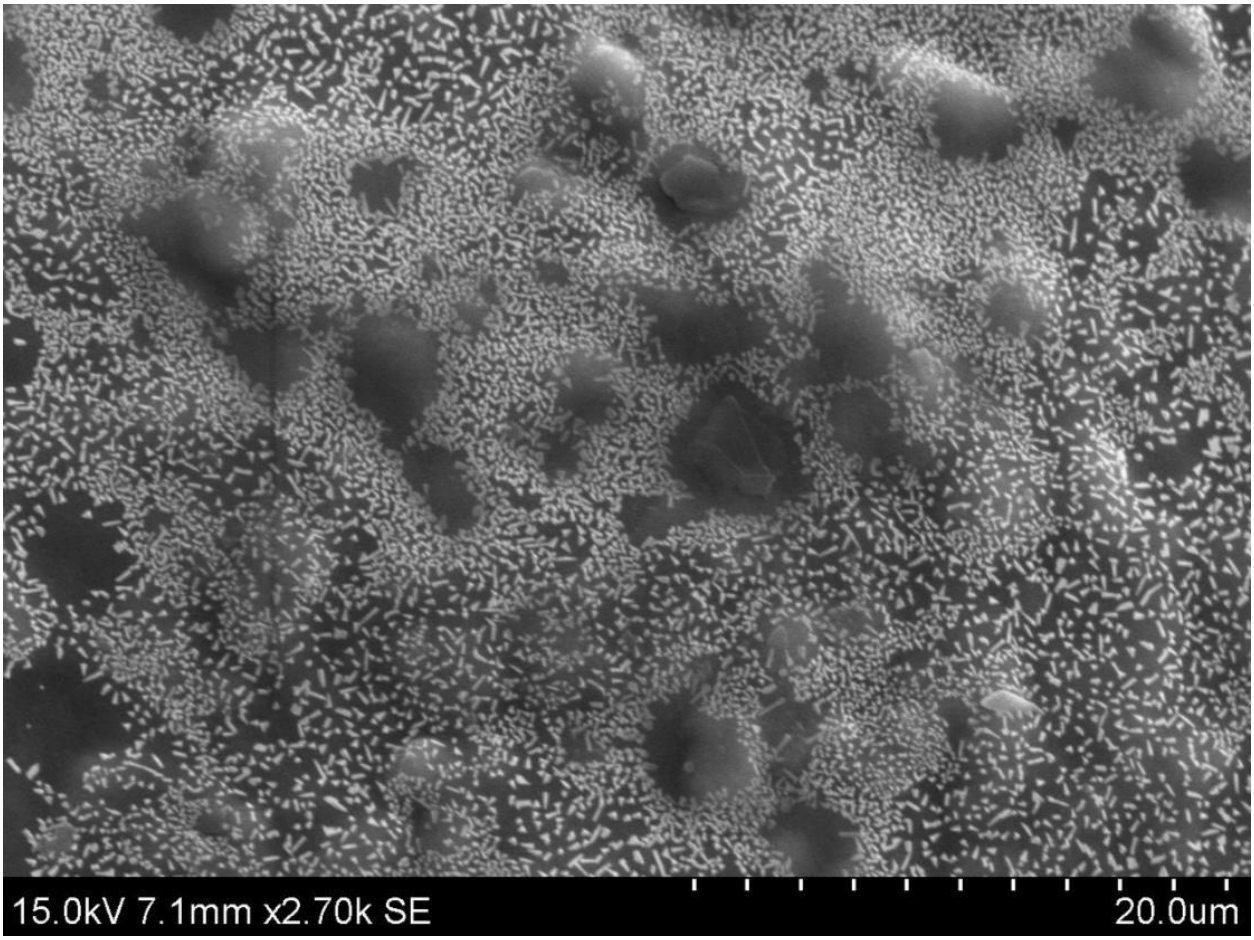


Figure 3 b: SEM Test

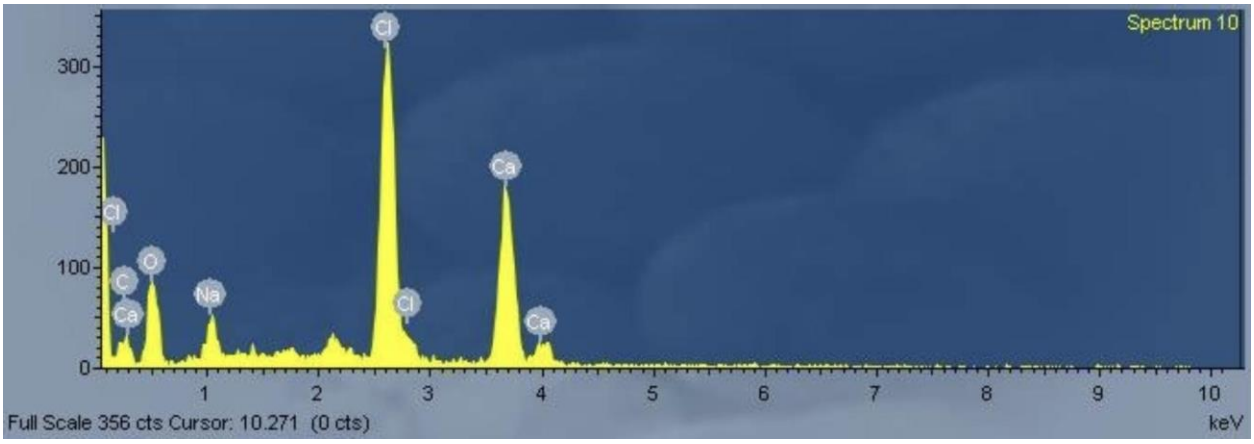


Figure 4 : EDS test

The sample is placed in a holder in the path of the IR source. A detector reads the analog signal and converts the signal to a spectrum. A computer is used to analyze the signals and identify the peaks. An IR beam goes through a partially silvered mirror, which splits the beam into two beams of equal intensity.Dopamine cross linked carboxymethyl cellulose is synthesized and confirmed FT IR spectrometry .

Dopamine cross linked carboxymethyl cellulose is synthesized and confirmed FT IR spectrometry [9]. The tensile strength is effective when CMC is cross linked with dopamine. From the previous studies,bulk adhesion property of the hydrogels was studied by lap shear tests. Results showed that the adhesion strength of CMC was indeed improved after modification by dopamine. The earlier study by Md. Saifur Rahman & Md. Saif Hasan explained that the prologue of carboxymethyl functional groups into the cellulose structure upsurges the hydrodynamic volume of the product, which concludes in a gradual enhancement of its viscosity which is inline with our study [10].

The Study conducted by Zuwu Tang & Yanan Maio [11] concluded that UV-resistant CMC hydrogels were urbanized by hosting CMC complexes into a polymer network, the polymer network harnessed the benefits of adhesiveness of PDA for promoting cell adhesion and excellent UV-resistant performance. The reliable biocompatibility and UV-shielding ability construct CMC hydrogels as a guaranteeing component in the applications for UV filtration membrane and skin care products. This study stands with the same conclusion of our Study.

The Study of Yanxia Yang & Yuanzhi Wu states that the carboxyl group and hydroxyl group as a polymer coating on the surface of CMC-DA adsorbed calcium and phosphorus and placed it on the surface of magnesium alloy beneath the electrostatic interaction. The novel coating has a dense three-dimensional leaf structure, additionally it is hydroxyapatite with good crystallinity. The coating can afford good corrosion resistance for magnesium alloy, and HA coating encourages cell proliferation thus providing a good prospect in medical implantation which concludes the same of our study [12].

From a previous study artificial catechol-based hydrogels are generally too simple considering their chemical composition and grade structure, resulting in poor mechanical strengths and bonding strengths [12,13]. From the previous study done on Natural polymer-based adhesive hydrogel suggested that the adhesion strength of CMC is low, and it is urgent to improve the adhesion performance through modification. Dopamine(DA) is a kind of amino acid, which can interact strongly with other materials through chemical and physical interaction and shows high adhesion on various materials [14] .

Citric acid-cross when linked with CMC-TG composite hydrogel films parades high drug loading with meticulous release of model drug. Haemolysis study signposted hemocompatibility of hydrogel films. The conclusion states that CMC-TG composite hydrogel films crosslinked with citric acid exhibit the potential to be used as a controlled or sustained drug delivery system for topical delivery. The study done by K.K.Mali & S.C.Dhawale concluded the same as of this study [15]

Another study done on Tough and tissue-adhesive polyacrylamide/collagen hydrogel with dopamine-grafted oxidized sodium alginate as a crosslinker for cutaneous wound healing showed that The adhesion of hydrogels is vital for wound repair [16]. The quinone or semi quinon hydrogel attached to tissues could act as an adhesive,hemostat ronment [17]. It easily reacts or sealant, which can prevent fluid leakage or bleeding from the groups on the skin, and tissue and promotes proper healing [18].

The custom of drug carriers has surfaced as an effective methodology to solve the issues of drug resistance. Amids the developed nanocarriers, CMC gels have engrossed the consideration of researchers attributable to their low cost, elevated drug-loading efficiency and less toxicity [19]. Additionally, CMC gels maintains drug concentration at a pre-set level for a long time through a slow release, thus reducing drug toxicity and side effects. Whilst CMC gels can load photosensitizers and chemotherapy drugs simultaneously, it appears plausible that CMC gels will play an vital role in the medical treatment. The study of Wenliang Zhang & Yining Liu concluded the same as in alignment of the current study [20].

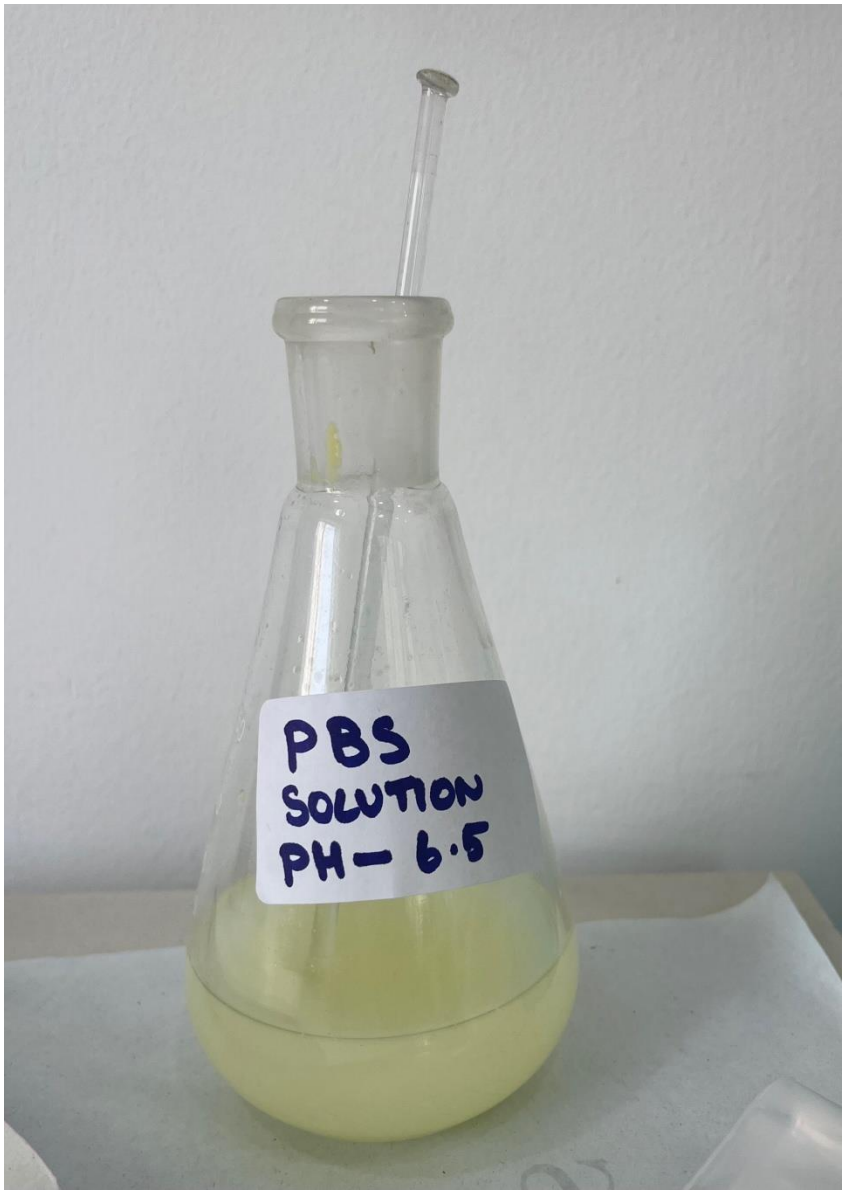


Figure 5 : PBS Solution

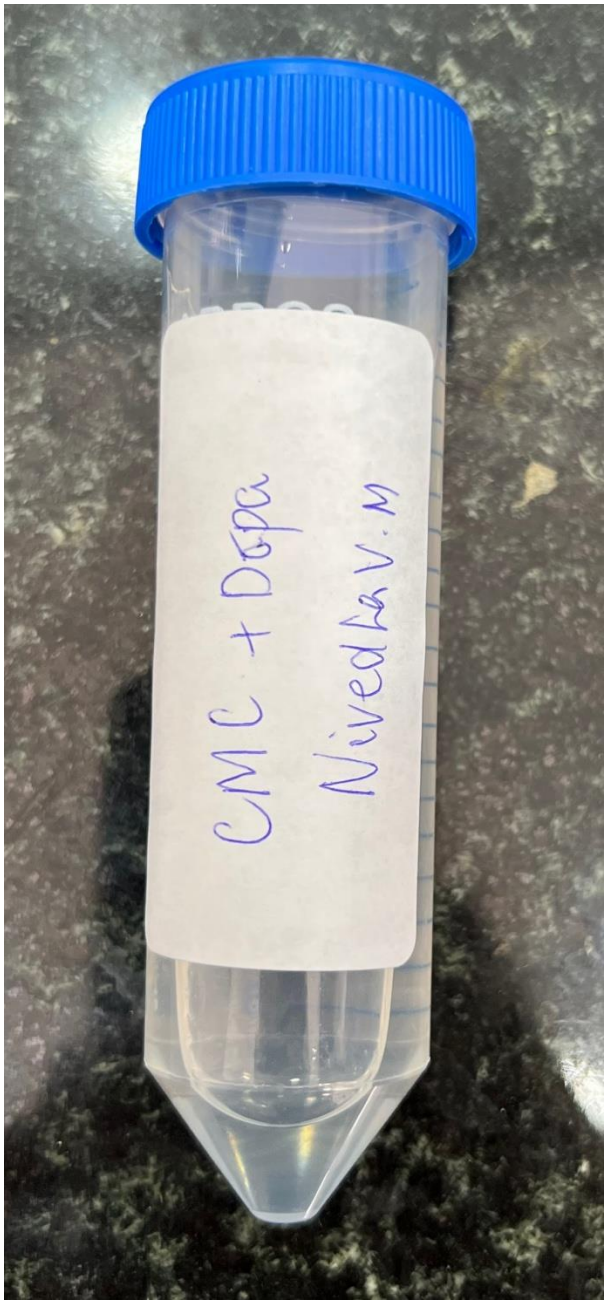


Figure 6 :carboxymethyl cellulose with dopamine

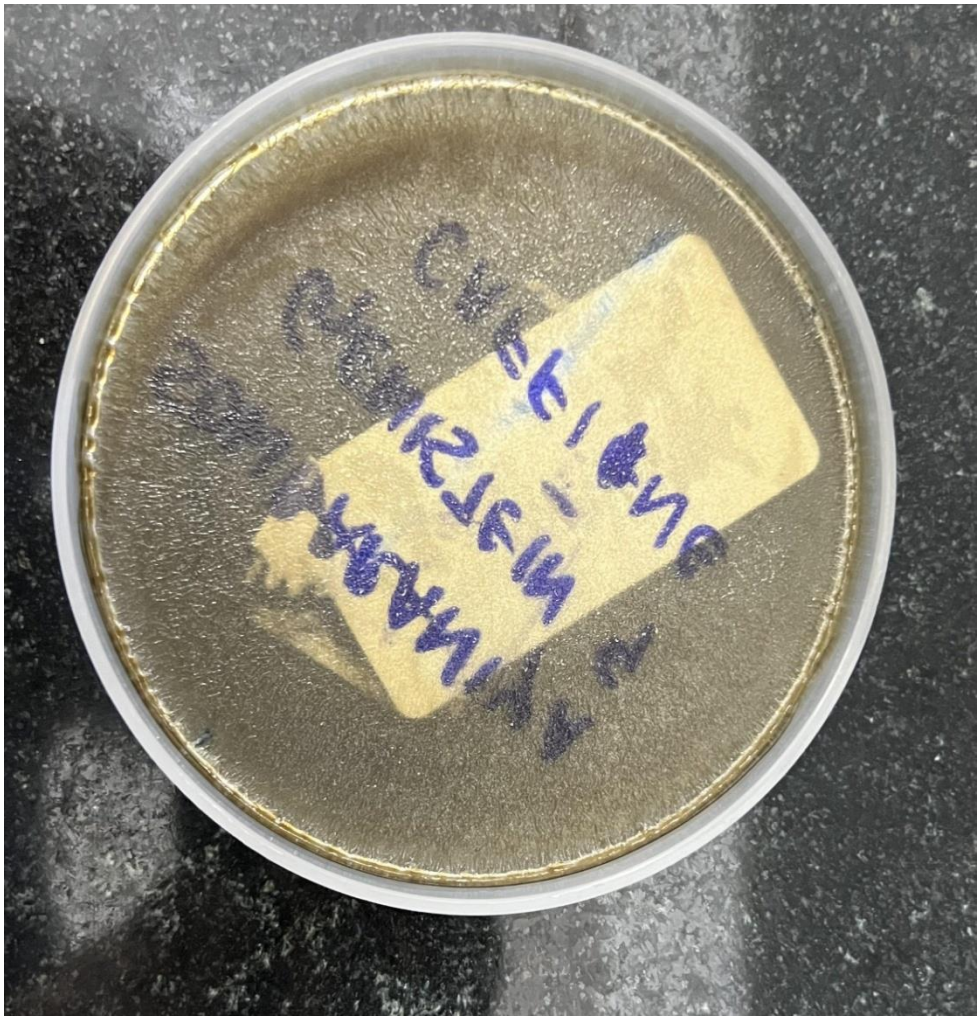


Figure 7 : After 24 hours of drying the solution dry strip formed.

Figure 8 :Samples were taken from the strip and sent for FT-IR spectroscopy, tensile strength test, SEM test .

Conclusion

Dopamine cross linked carboxymethyl cellulose are synthesized and confirmed FT IR spectrometry.The tensile strength is effective when CMC is cross linked with dopamine.From the previous studies,bulk adhesion property of the hydrogels was studied by lap shear tests. Results

showed that the adhesion strength of CMC was indeed improved after modification by dopamine. This study concludes that when dopamine is cross linked with CMC it has a better adhesive property.

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