Comparing the Efficacy of HydroxypropylMethyl Cellulose Oral Mucoadhesive Patchesfor Sustained Drug Delivery

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**Abstract:** Novel drug delivery systems have become more demanding in recent years. In the last two decades, Mucoadhesive systems have been considered a novel and suitable drug delivery route with better and more effective treatment. The mucoadhesive drug delivery system utilizes the property of bio adhesion of certain water-soluble polymers which have become adhesive on hydration and hence are used for targeting a drug to a particular region of the body for an extended period. Among the varying transmucosal routes, buccal mucosa provides a positive outlook and a new concept for controlled drug delivery. This study aims to synthesize and compare the efficacy of mucoadhesive patches of 9%,10%,11% hydroxypropyl methylcellulose to evaluate its capacity for effective drug delivery.The mucoadhesive patch was fabricated, which comprises two layers, an inner hydrophilic and an outer hydrophobic layer. The inner layer is made up of 10 grams of hydroxypropyl methyl-cellulose (PMC) and the efficacy was compared with 9 grams and 11 grams of PMC. The drug release was analysed using continuous flow method (CF), morphology using (SEM), tensile strength using tensile testing machine, antibacterial activity and hemocompatibility were also analyzed.SEM analysis revealed, 10% base shows optimal porosity whereas in 9% , high porosity was observed and 11% showed dense porosity. Within 72 hrs, 80% of the drug was released from the membrane. The 10% base showed better tensile strength than others.Comparatively, the 10% base showed limited degradation than (9%) and (11%)PMC. A significant amount of antibacterial activity was noted while testing with 50mg and 100mg of amoxicillin and lidocaine. Based on all the analyzed parameters, the base at 10% showed more optimal results especially for better adhesion, porosity, when compared to lower and higher composition bases.

**Keywords:** Comparative effectiveness research (CER), Drug delivery, Scanning electron microscopy (SEM), Biocompatibility, Antimicrobials/Antimicrobial resistance, Adhesives.

# INTRODUCTION

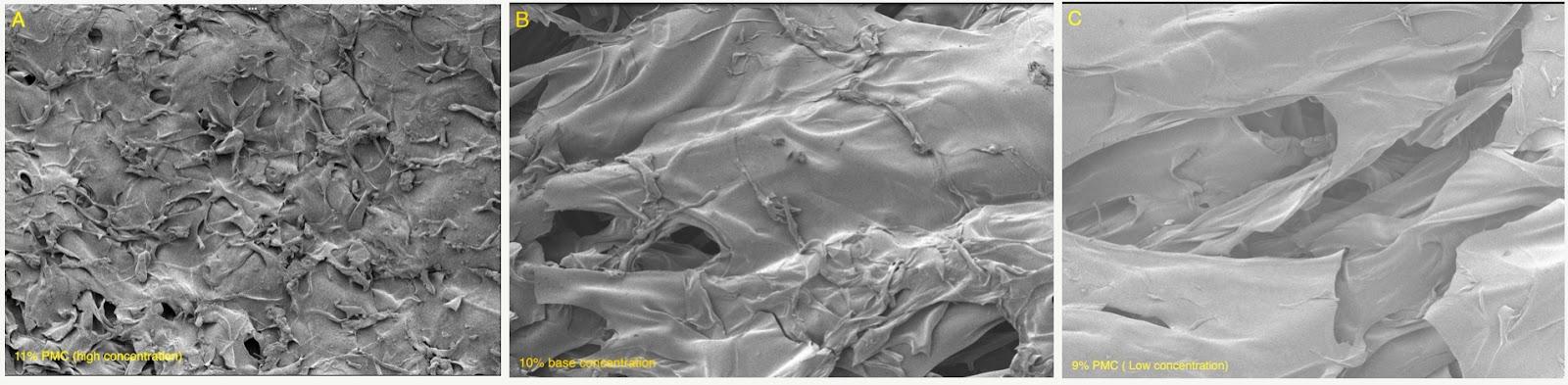
Medication delivery via buccal means offers an alluring substitute for medication administration by mouth, especially when it comes to mitigating the drawbacks of the latter method[(Ealla et al., 2025)](https://paperpile.com/c/UPRyxn/CnKcs)(Reddy et al., 2012). For formulations intended for specific reasons like taste masking, a quicker beginning of therapeutic effect, localized treatment, or avoiding first-pass metabolism, drug release within the oral cavity can be crucial[(Chen & Engelen, 2012)](https://paperpile.com/c/UPRyxn/92vvN)(Murthykumar K et al., 2019)[(Rajeshkumar & Lakshmi, 2021; Sivakumar et al., 2021)](https://paperpile.com/c/UPRyxn/vOhdI+PeLv3). Effective drug distribution through the oral mucosa is both a constant source of challenge and significant potential[(Khutoryanskiy, 2014)](https://paperpile.com/c/UPRyxn/RxyOe). With new methods constantly being developed, oral transmucosal delivery -particularly buccal and sublingual delivery has advanced well beyond the use of conventional dosage forms[(Khutoryanskiy, 2020)](https://paperpile.com/c/UPRyxn/2ZYgw)(Ruparthy B et al, 2025)[(Gandhi et al., 2021; Katyal et al., 2023; Priyadharshini et al., 2023)](https://paperpile.com/c/UPRyxn/u6dF+VGz4+CjrF). Because of its low cost, convenience of administration, and high level of patient compliance, the oral route is the most recommended method for the delivery of therapeutic substances[(Rathbone, 1996)](https://paperpile.com/c/UPRyxn/yTyEP)[(Chokkattu et al., 2023; Dharman et al., 2023; Govindaraj & Shanmugam, 2023)](https://paperpile.com/c/UPRyxn/G1A5+AXmO+bwiA) By giving medications via the buccal route, issues including first-pass metabolism and drug degradation in the hostile gastrointestinal environment can be avoided[(R et al., 2024)](https://paperpile.com/c/UPRyxn/nOX47). Additionally, the oral cavity is easily accessible for self-medication, and withdrawing the dose form from the buccal cavity can quickly stop the medicine if toxicity occurs[(Khutoryanskiy, 2014)](https://paperpile.com/c/UPRyxn/RxyOe)[(Muttil & Kunda, 2020)](https://paperpile.com/c/UPRyxn/A1QIw)[(Janani et al., 2021; Kachhara et al., 2021; Subramanian et al., 2023)](https://paperpile.com/c/UPRyxn/hg4s+2iMe+HiDO). The mucoadhesive buccal patch is a potentially effective oral medication delivery dosage form that offers special benefits for a range of applications, including the treatment of post-dental surgery problems and periodontal disease[(Wen & Park, 2011)](https://paperpile.com/c/UPRyxn/rfsc6)[(Anand et al., 2023; Prabhu Venkatesh et al., 2024)](https://paperpile.com/c/UPRyxn/c5ZT+KGcl)[(Doshi et al., 2023; Lampl et al., 2023; Pandiyan et al., 2023)](https://paperpile.com/c/UPRyxn/JIxx+GXC7+H8JV)[(Anand et al., 2023; Prabhu Venkatesh et al., 2024)](https://paperpile.com/c/UPRyxn/c5ZT+KGcl)[(Pavithra et al., 2023; Shenoy et al., 2023; Thomas & Jain, 2023)](https://paperpile.com/c/UPRyxn/jeMI+IBUm+8Txu). The study aims at developing a mucoadhesive patch with commercially available cellulose and comparing its concentration to study its performance like drug delivery, hemocompatibility, tensile strength, degradation, SEM and also antimicrobial assay to evaluate whether the mucoadhesive patch meets the requirements[(Mittal et al., 2020)](https://paperpile.com/c/UPRyxn/q5Fog)[(Niyogi et al., 2017)](https://paperpile.com/c/UPRyxn/cHSOn)[(Ramsundar et al., 2023; Rieshy et al., 2023; Singh et al., 2023)](https://paperpile.com/c/UPRyxn/0hJ2+HDnv+TZ4B)[(Rajeshkumar & Lakshmi, 2021; Sivakumar et al., 2021)](https://paperpile.com/c/UPRyxn/vOhdI+PeLv3)

# MATERIALS AND METHOD

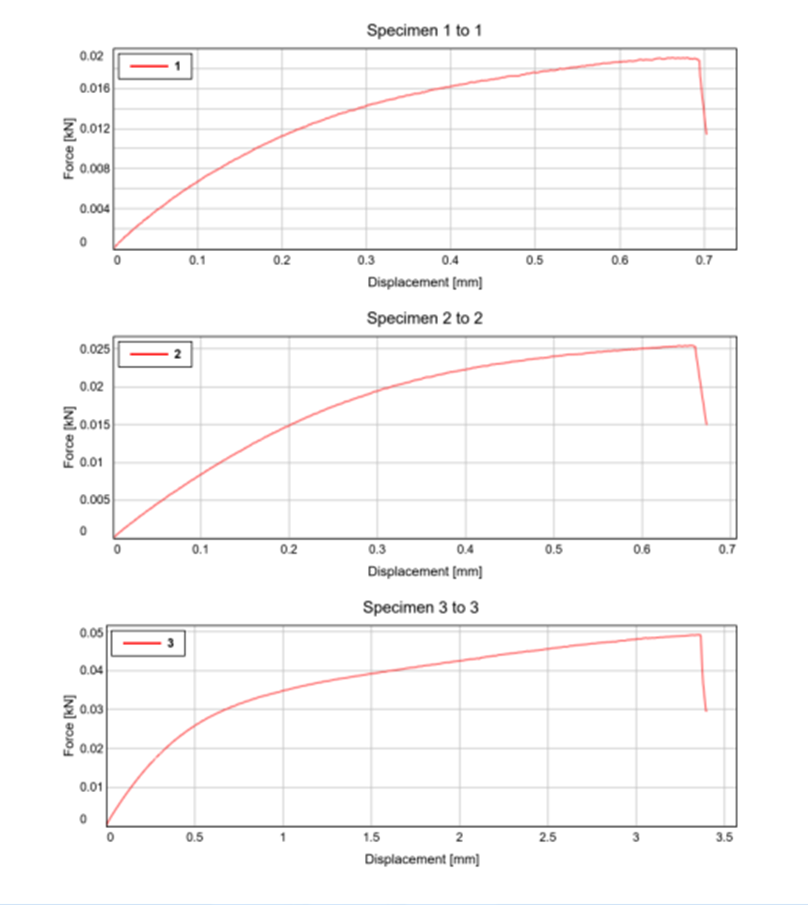
Fabrication of mucoadhesive patch: the patch comprised of two layers- An inner hydrophilic layer - 10 grams of hydroxypropyl methyl cellulose(PMC) in 100 ml of distilled water and an outer hydrophobic layer which was lyophilised. For comparing the adhesive nature we have also formulated 9 grams and 11 grams of PMC. In the hydrophilic layer, we are incorporating drugs to evaluate the drug release capacity of the inner adhesive layer. Drugs loaded are Amoxicillin 100mg, LA lignocaine with adrenaline 250ul, and Flagyl 100mg. Incubation duration for 1 week- petri dish at room temperature to evaluate drug release, Morphology of the patch is analyzed through Scanning Electron Microscopy(SEM) to evaluate the microporosity which channels drug release. Tensile strength to know whether the patch can bear the maximum stress required is examined under a universal testing machine. The patch is kept under artificial saliva to evaluate its stability for 1, 3 and 5 days. In addition, we have also investigated antibacterial activity using the agar well diffusion method, with bacteria like Staphylococcus aureus and Escherichia coli being used.

# RESULTS

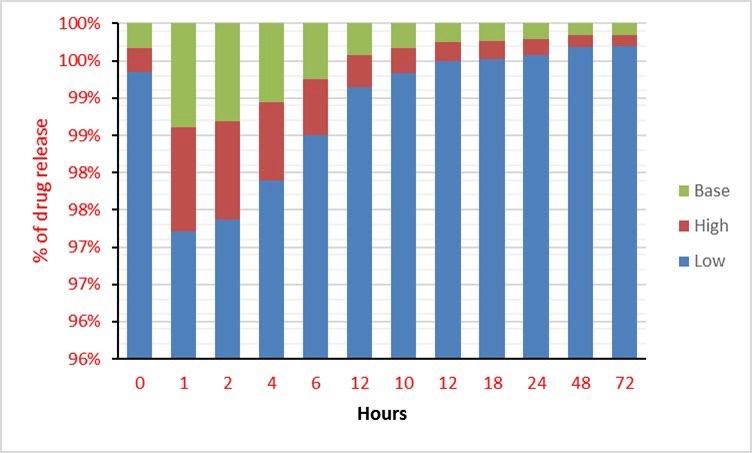
The morphology of the mucoadhesive patch is viewed under structural electron microscopy. In Group 1 (9% PMC) high porosity is observed. Group 2( 11%PMC) shows a dense porous structure. Group 3(10% base PMC) shows optimal porosity(figure 1). The drug release is recorded on an hourly basis, in this review we have noted 80% of drug release from the membrane within 72 hours(figure 3). Tensile strength is evaluated in a universal testing machine where the 10% base group shows better tensile strength than other groups(figure 2). The stability of the mucoadhesive patch depends mainly on its degradation value. On an in-vitro degradation, group 3 (10% base) shows comparatively less degradation than group 1 (9% PMC) and group 2 (11% PMC)(figure 4). In addition Antibacterial assay and hemocompatibility were also evaluated. Staphylococcus aureus and Escherichia coli have been used, group 3 (10% base) shows a significant amount of antibacterial effects while tested with 50mg and 100mg(figure 5).



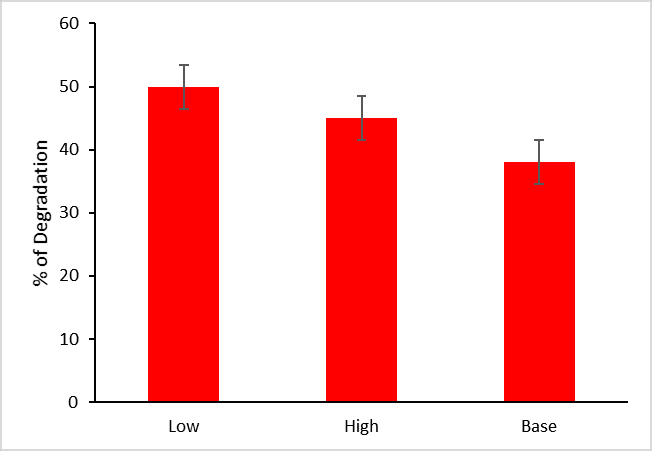
**Figure 1:** SEM analysis showing A: 11% showing dense porous structure, B: 10% showing limited porosity and C: 9% with high loosely porous morphology is observed.



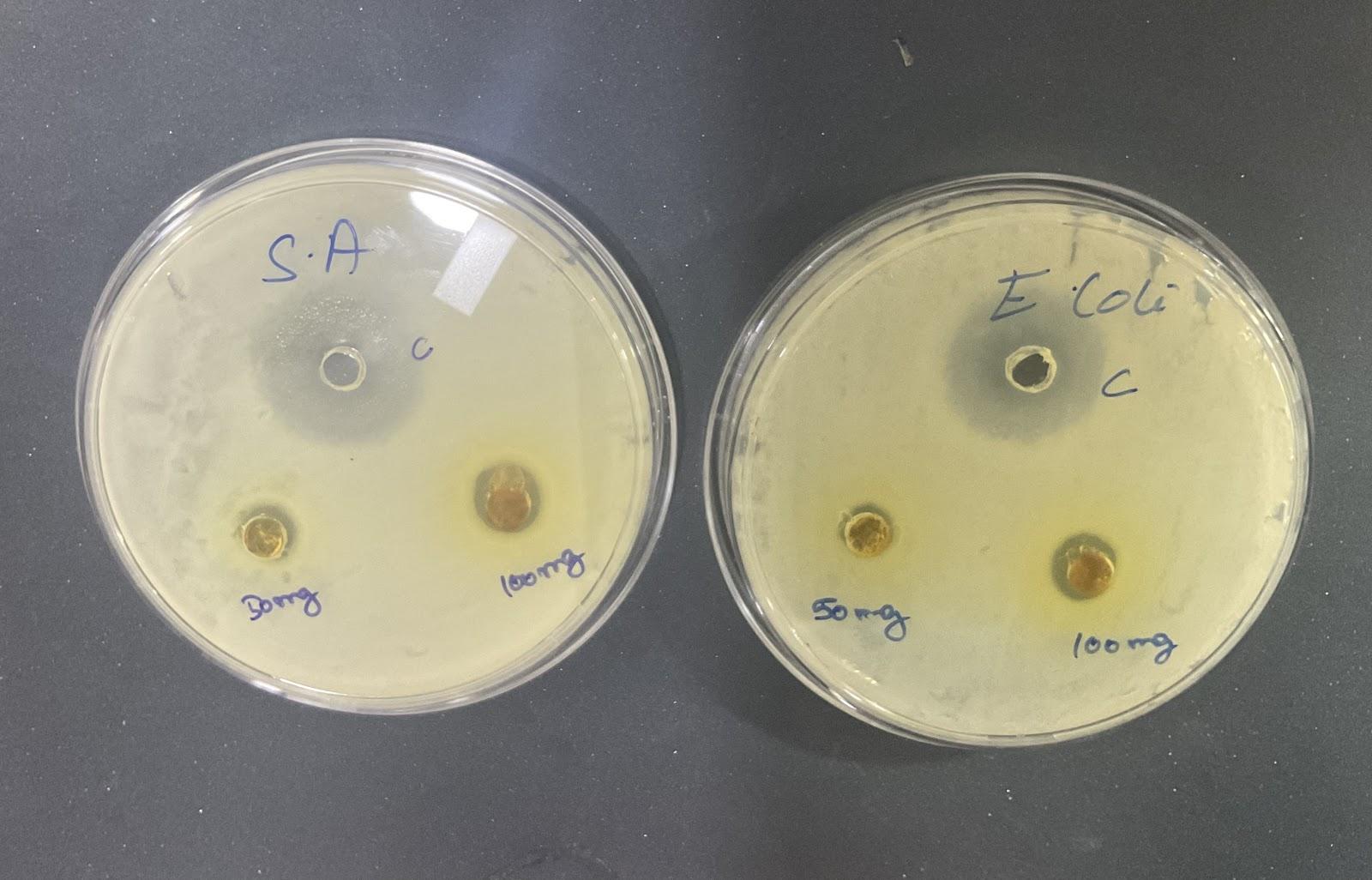
**Figure 2:** Tensile strength with relative force and displacement.



**Figure 3:** Table showing results of drug release of base(10%), high concentration(11%) and low concentration(9%) in every hour.



**Figure 4:** Biodegradation status of 9%,11% and 10% hydroxypropyl methylcellulose patch.



**Figure 5:** Antibacterial assay showing zone formation in 10% base hydroxypropyl methylcellulose patch composed of amoxicillin in 50mg and 100mg.

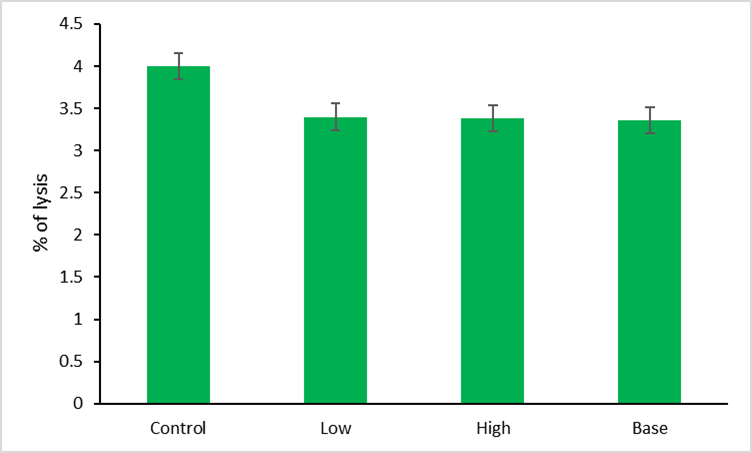
# DISCUSSION

Fixing an oral recurrent apthous ulcer or any breach in the oral mucosa with an adhesive patch strikes a key appealing philosophy to reduce pain and supply medication in the same location while avoiding contact with anything that causes pain to an open sore. In this study we have formulated a mucoadhesive patch with commercially available cellulose material and analyzed many criteria which helps in enhancing the method of administering the medicine (Rafi et al., 2024). Study done by pakfetrat et all in 2024, used mucoadhesive patch with N.sativa extract for wound dressing additionally it addresses burning sensation, paina[(Pakfetrat et al., 2024)](https://paperpile.com/c/UPRyxn/R7eOf). In our study, a mucoadhesive patch consists of two layers (Tuluwengjiang et al., 2024). The inner hydrophilic layer is because the patch has to adhere to the oral mucosa without dislodgement, and an outer hydrophobic layer manages to elute saliva over the patch. The inner hydrophilic layer is made of hydroxypropyl methylcellulose in varying concentrations like 9%, 10% and 11%. The outer hydrophobic layer is synthesized from the polycaprolactone layer. One of the most popular experimental techniques for examining and analyzing micro- and nanoparticle imaging and characterisation of solid objects is the scanning electron microscope (SEM). A factor contributing to SEM's popularity in particle size analysis is its 10 nm, or 100 Å, resolution. In an article, the author analyzed patch under SEM for uniform spread of drugs[(Popovici et al., 2022)](https://paperpile.com/c/UPRyxn/InDuA) In this study, we have analyzed different concentrations of mucoadhesive cellulose patch under SEM to evaluate the porosity created after lyophilization. The higher the porosity, the faster will be the drug release. Group 1 (9% PMC) shows loosely arranged structure with high porosity while in Group 2 (11% PMC) the densely packed matrix shows low porosity and in Group 3 (10% PMC) shows significant amount of porosity. Drug stability, therapeutic outcomes, and formulation development are all directly impacted by drug-release behavior, making it a crucial component of polymer nanoparticle use[(Siepmann et al., 2011)](https://paperpile.com/c/UPRyxn/y3xUm). Mucoadhesive patch medication delivery has been employed in a research to treat oral submucous fibrosis. It demonstrated continuous drug release [(Cheng et al., 2023)](https://paperpile.com/c/UPRyxn/ymbZV). In this study all the three inner surfaces of the patches were incorporated with Amoxicillin 100mg, Lignocaine with adrenaline 250ul, Flagyl 100mg where kept in a petri dish at room temperature for 1 week to analyze the drug release in an hourly manner. Among the three patch’s base shows more than 80% of drug release within 72hrs from the membrane. Tensile strength is a crucial material attribute that affects how well a material performs mechanically. It is a material's capacity to withstand tearing brought on by stress.Tensile strength in this study is analyzed via a universal testing machine[(Roters et al., 2011)](https://paperpile.com/c/UPRyxn/6vDMS) 9% PMC ( group 1) withstands force of 0.02kN without displacement up to 0.7mm. In 11%PMC (group 2), it withstands force of 0.025kN without dislodgement up to 0.7mm. And in 10%PMC(group 3), it can withstand force of 0.05kN without displacement up to 3.5mm. Showing results favors 10% PMC patch. Organic matter is broken down by bacteria through a process called biodegradation. This can take days, weeks, or even centuries, depending on the material[(Saxena et al., 2011)](https://paperpile.com/c/UPRyxn/tjZXp). The mucoadhesive patch of three different concentrations was tested for its stability and it shows varying results like 9%PMC for 50% degradation, 11% PMC shows 45% degradation and 10% PMC shows 40% degradation over time. The lower the degradation the higher will be its efficacy.,

# CONCLUSION

Upon scrutinizing the parameters, it becomes evident that 10% PMC yields noteworthy outcomes across all assessments. Therefore, using a 10% PMC concentration as a mucoadhesive patch is a logical alternative. Overall, these findings suggest that these 10% PMC patches could be used as mucoadhesive drug delivery systems to treat oral cavity diseases.

## SUPPLEMENTARY FILES



**Figure 6:** Hemolysis of 9%, 11% and 10% hydroxypropyl methylcellulose patch

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