World Bulletin of Education and Learning (WBEL)
ISSN (E): 3072-175X
Volume 01, Issue 01, October 2025

https://worldbulletin.org/index.php/1

STUDY OF THE DIFFUSION KINETICS OF DICLOFENAC SODIUM FROM CARBOMER-BASED HYDROGEL AND ORGANOGEL MATRICES

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Abstract
This article presents the results of a study devoted to investigating the diffusion and physicochemical properties of gel matrix ointments prepared on the basis of carbopol and sodium carboxymethyl cellulose (Na-CMC). The advantages of topical dosage forms, their direct effect on the affected area, and their ability to reduce systemic side effects are scientifically substantiated. The research aimed to obtain an effective bio-compatible, viscous, and highly diffusive matrix by introducing Na-CMC into hydrogel and organogel compositions to reduce the amount of carbopol. The diffusion kinetics of diclofenac sodium released from the polymer matrix were studied using the Franz diffusion cell method. Based on the obtained UV–vis spectrum results, the absorbance at a wavelength of 276 nm was determined, and a linear equation ($A=0.0036C–0.0031$) with a high correlation coefficient ($R^2=0.9875$) was established. These results reveal the potential for compositional optimization of gel-based drugs and hold significant practical importance in the development of pharmaceutical ointment formulations.

Keywords: Carbopol, sodium carboxymethyl cellulose, hydrogel, organogel, diffusion kinetics, Franz diffusion cell, diclofenac sodium, UV–vis spectrum, pharmaceutical matrix.

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Introduction

KARBOMER ASOSIDAGI GIDROGEL VA ORGANOGEL MATRITSALARDAN DIKLOFENAK NATRIYNING DIFFUZIYALANISH KINETIKASINI O'RGANISH

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Annotatsiya

Mazkur maqolada karbopol va natriy karboksimetilsellyuloza (Na-KMS) asosida tayyorlangan gel matritsali surtma dorilarning diffuzion va fizik-kimyoviy xususiyatlarini o'rganishga bag'ishlangan tadqiqot natijalari keltirilgan. Mahalliy dori shakllarining afzalligi, ularning to'g'ridan-to'g'ri zararlangan joyga ta'sir etishi hamda tizimli nojo'ya ta'sirlarni kamaytirish xususiyati ilmiy asoslab berilgan. Tadqiqotda gidrogel va organogellar tarkibiga Na-KMS kiritish orqali karbopol miqdorini kamaytirish bilan samarali bio-mos, qovushqoq va yuqori diffuziya xususiyatlariga ega matritsa olish maqsad qilingan. Franz diffuziya hujayrasi usuli yordamida diklofenak natriyning polimer matritsadan ajralib chiqish kinetikasi o'rganilgan. Olingan UV–vis spektr natijalari asosida 276 nm to'lqin uzunligida yutilish ko'rsatkichi aniqlanib, chiziqli tenglama (A=0.0036C–0.0031) va yuqori korrelyatsiya koeffitsiyenti (R^2=0,9875) qayd etilgan. Ushbu natijalar gel asosidagi dorilarning tarkibiy optimallashtirish imkoniyatlarini ochib beradi hamda farmatsevtik surtma shakllarini ishlab chiqishda muhim amaliy ahamiyat kasb etadi.

Kalit so'zlar: karbopol, natriy karboksimetilsellyuloza, gidrogel, organogel, diffuziya kinetikasi, Franz diffuziya hujayrasi, diklofenak natriy, UV–vis spektr, farmatsevtik matritsa.

Relevance of the study: In modern pharmaceutics, the demand for topical dosage forms is steadily increasing, as they act directly on the affected area and reduce

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systemic side effects. Hydrogels and organogels based on Carbopol and Sodium Carboxymethyl Cellulose (Na-CMC) are of particular importance due to their biocompatibility, non-toxic nature, as well as swelling and viscosity properties.

Purpose of the study: To obtain a matrix with effective diffusion and physicochemical properties by reducing the amount of Carbopol in Carbopol-based gel matrix ointments through the introduction of Na-CMC.

Hydrogels are three-dimensional structures capable of absorbing and retaining a large amount of water without losing their structural integrity [1]. Hydrogels are inherently very stable; as a result, the absorbed solution remains within the polymeric network even when exposed to external forces [2]. Due to the presence of a large number of hydrophilic groups such as –OH, –HSO3, –COOH, and –NH2 in the polymer chain, hydrogels exhibit a high capacity for water absorption [3,4]. The Carbopol polymer belongs to the same group of polymers. When its macromolecule is neutralized with an aqueous solution of NaOH, the polymer chains expand to their maximum distance (swell).

In a study conducted by Muhammad Suhail, Pao-Chu Wu, and Muhammad Usman Minhas, an in vitro analysis of Carbomer-based hydrogel formulations was carried out in both acidic (pH 1.2) and basic (pH 7.4) environments, revealing greater drug release at pH 7.4. The release kinetics of drugs from hydrogels were mathematically modeled using zero-order, first-order, Higuchi, and Korsmeyer–Peppas models [5].

Methods and methodology: In this scientific study, we examined the diffusion kinetics of drug particles from hydrogels and organogel polymer matrices based on carbopol, certain cellulose derivatives, and their mixtures using the Franz diffusion cell method. In this method, a quartz vessel's donor chamber is filled with a hydrogel or organogel sample containing diclofenac sodium particles. The receptor chamber is filled with a phosphate buffer solution (pH = 6.86), as diclofenac sodium remains stable in neutral environments. The concentration of diclofenac sodium diffused (vertical diffusion) through a cellulose membrane from the sample in the donor chamber was determined using a spectrophotometric method **(Figure 1).**

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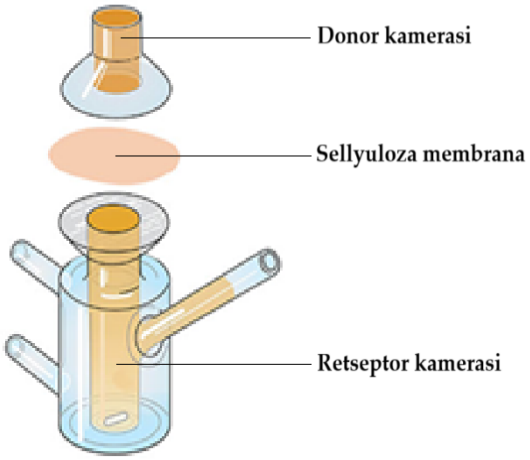

Figure 1: Franz diffusion cell method

Results:

For this purpose, standard solutions of diclofenac sodium in phosphate buffer were prepared. The standard solutions were obtained at concentrations of 2 µg/ml, 4 µg/ml, 6 µg/ml, 8 µg/ml, 10 µg/ml, and 12 µg/ml. The UV–vis spectra of the prepared standard solutions and the linear relationship between absorbance and concentration were determined and graphically represented (Figure 2). The standard solutions of diclofenac sodium in phosphate buffer exhibited a characteristic absorption peak at a wavelength of 276 nm in the UV–vis spectrum. The intensity of this peak was found to be dependent on the concentration of diclofenac sodium in the solution, and the corresponding absorbance values are presented in Table 1 below.

1-Table:

Samples	S1 ($2\mu g/ml$)	S2 ($4\mu g/ml$)	S3 ($2\mu g/ml$)	S4 ($2\ \mu g/ml$)	S1 ($2\ \mu g/ml$)

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Absorbance at 274 nm	0.003084	0.012983	0.017346	0.024383	0.032796

Based on the obtained results, the amount of diclofenac sodium present in the solution was determined using the following linear equation, which relates concentration to absorbance:

$A = 0.0036C - 0.0031$.

In this case, the correlation coefficient was found to be $R^2 = 0.9875$ (Figure 3).

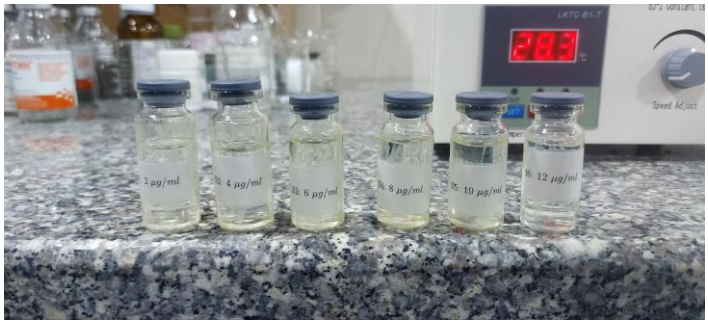

Figure 2: Standard solutions of diclofenac sodium in phosphate buffer solution

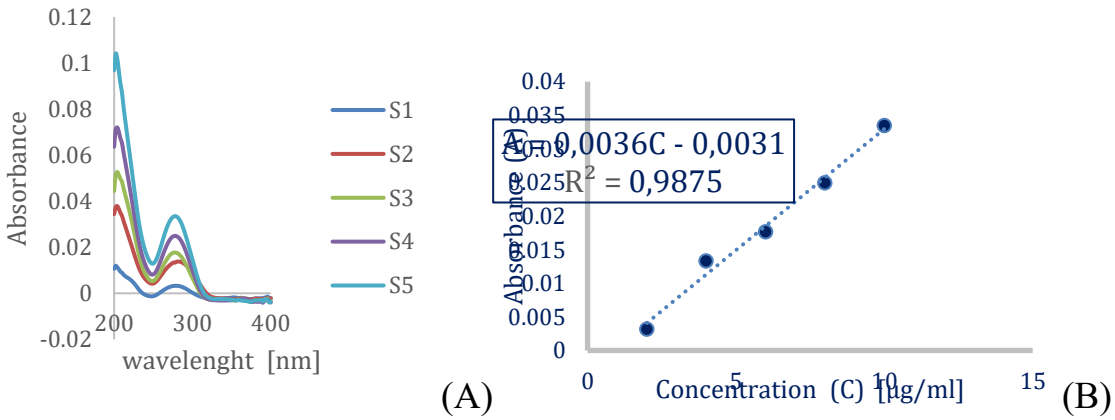

Figure 3: UV–vis spectra of standard solutions of diclofenac sodium in phosphate buffer (2 µg/ml, 4 µg/ml, 6 µg/ml, 8 µg/ml, 10 µg/ml) (A) and the relationship between concentration and absorbance.

Conclusion: Scientific studies are being carried out to determine the concentration of diclofenac sodium in phosphate buffer solution at time intervals

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of 0.5 hour, 1 hour, 1.5 hours, 2 hours, 2.5 hours, and so on, in order to study the time-dependent release kinetics.

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