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A Simple Liquid – Liquid Extraction Method for Carmine dye (E120) Using Amberlite LA-2 as ion-Exchanger

Abdulrahman Dnkm[1,2], Zamzam Basher[2], Eman Aljelani[1] and *Aisha Al-Abbasi[1]

[1]Chemistry Department, Faculty of Science, Sebha University, Libya
[2]Department of Chemistry, Faculty of Tragen, Fezzan University, Libya

*Corresponding Author email: ais.alabbasi@sebhau.edu.ly

Abstract

This study presents a simple and effective method for extracting carmine dye from its aqueous solutions using Amberlite LA-2 liquid extractant. The effect of several operating factors on extraction efficiency was studied, such as Amberlite concentration (0.011, 0.022, 0.044, 0.088, 0.132), initial dye concentration (20, 40, 60, 80, 100, 140), contact time ranging from 15 to 180 minutes, and pH ranging from 2 to 13. The results showed that optimal conditions were achieved at an amine concentration of 0.044 molar, a contact time of 60 minutes, and an acidic medium at pH=2, where the highest extraction efficiency of 74.018% and a distribution coefficient of 2.849 were recorded. The study included the analysis of commercial samples of lipstick and candy, where the concentration of carmine reached 140.858 ppm in lipstick with an extraction efficiency of 80.17%, while its concentration reached 185.857 ppm in M&M candy with an extraction efficiency of 48.08%, indicating the effectiveness of the method in the quantitative and qualitative detection of the dye in industrial samples.

Keywords*:* Carmine, Amberlite LA-2, Liquid-Liquid Extraction, Ion Exchanger, Spectrophotometry.

طريقة استخلاص سائل – سائل بسيطة لصبغة الكارمين (E120) باستخدام Amberlite LA–2 كمبادل أيوني

عبد الرحمن دنكم[1،2]، زمزم بشير[2]، إيمان الجيلاني[1] و *عائشة العباسي[1]
[1]قسم الكيمياء، كلية العلوم، جامعة سبها، ليبيا
[2]قسم الكيمياء، كلية تراغن، جامعة فزان، ليبيا

*البريد الإلكتروني للمؤلف المراسل: ais.alabbasi@sebhau.edu.ly

ملخص

تقدم هذه الدراسة طريقة بسيطة وفعالة لإستخلاص صبغة القرمزي من محاليلها المائية. تم إجراء عملية الإستخلاص باستخدام طريقة الإستخلاص السائل–السائل باستخدام Amberlite LA–2 كمستخلص. تم استخدام التحليل الطيفي للأشعة فوق البنفسجية والمرئية لتحديد تركيز الصبغة في محلول مائي عند أقصى طول موجي للامتصاص البالغ 514 نانومتر . تمت دراسة تأثير عدة عوامل تشغيلية على كفاءة الاستخلاص، مثل تركيز Amberlite (0.011، 0.022، 0.044، 0.088، 0.132)، وتركيز الصبغة الأولي (20، 40، 60، 80، 100، 140)، ووقت التلامس الذي يتراوح من 15 إلى 180 دقيقة، ودرجة الحموضة التي تتراوح من 2 إلى 13. أظهرت النتائج أن الظروف المثلى تحققت عند تركيز أمين 0.044 مولار، ووقت تلامس 60 دقيقة، ووسط حمضي عند درجة حموضة pH=2، حيث سُجلت أعلى كفاءة استخلاص بنسبة 74.018٪ ومعامل توزيع 2.849. تضمنت الدراسة تحليل عينات تجارية من أحمر الشفاه والحلوى، حيث بلغ تركيز الكارمين 140.858 جزء في المليون في أحمر الشفاه بكفاءة استخلاص 80.17٪، بينما بلغ تركيزه 185.857 جزء في المليون في حلوى M&M بكفاءة استخلاص 48.08٪، مما يشير إلى فعالية الطريقة في الكشف الكمي والنوعي للصبغة في العينات الصناعية.

الكلمات المفتاحية: القرمزي، Amberlite LA–2، الاستخلاص السائل–السائل، المبادل الأيوني، القياس الطيفي الضوئي.

1. Introduction

Appealing colors enhance the palatability of food. Color, perhaps more than any other factor, influences consumer acceptance of products. Foods with distinctive appearance and color are generally preferred. Therefore, the food industry has resorted to enhancing food color to increase consumer acceptance. Food colors can be primarily classified into natural colors [1, 2] and artificial colors [2-4]. The problems that have arisen from the use of artificial colors have led to a reconsideration of the quantities permitted in the food industry and, in some cases, the prohibition of certain colors for health reasons. Many studies have shown that these colors can cause illnesses, including cancer, allergies, and children's hyperactivity. Colorants are designated by the symbol (E) followed by numbers from 100 [6 ،5 ،2].

A whole range of plants can be used to extract plant dyes [4]. Some insects also contain pigments, the most famous being carmine. The carmine dye is obtained naturally by extracting it after a specific treatment of the female carmine beetle (Figure 1) [1, 7]. This beetle lives in Central and South America and various regions such as Mexico, the Caribbean, and Brazil, and it is found as a parasite on plants [1, 7].It is used in the preparation of certain types of ice cream, candies, and marmalade.

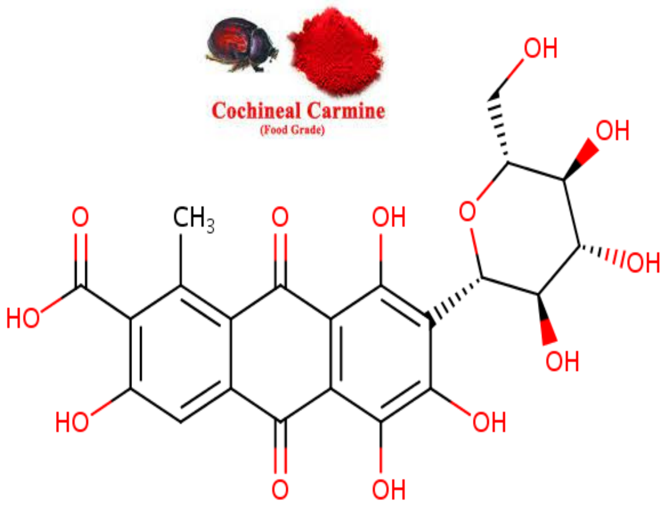

Fig. 1: Carmine Dye - Color, Source, and Chemical Composition [1]

Carminic acid is an anthraquinone derivative [8 ،7 ،1]. Carmine is known as a food coloring that can cause severe allergic reactions and anaphylactic shock in some people. Carmine dye is not permitted in most countries due to its potential to cause allergies in children or other long-term health problems, particularly for vegetarians, and especially for those adhering to religions like Islam, as the dye is derived from an insect. [9 ،6 ،5 ،2].

N-Lauryl (trialkylmethyl) amine (LA-2) is a liquid secondary amine with a high molecular weight, soluble in most common (nonpolar) organic solvents. This solubility, along with the ability of secondary amines to react with acids to form the corresponding amine salts [7, 8], contributes to its solubility. A laboratory study was conducted on a liquid-liquid extraction system using Amberlite LA-2 to remove and purify many organic chemicals from their aqueous solutions, with organic acids being the most frequently extracted. This secondary amine exhibited high extraction efficiency for several acids, including L(+) Tartaric Acid [10], Maleic Acid [11], Glycolic Acid [27]. Regarding the removal of dyes using Amberlite LA-2, no previous studies were found.

Building on our previous work [10-16] in using Amberlite LA-2 as an extractant, and given that carmin dye is an anionic organic dye containing ionizable hydroxyl and carboxyl functional groups, it can form stable ion pairs with basic extractants. Amberlite LA-2 exhibits strong anion-exchange properties and a high affinity toward acidic compounds, making it a promising candidate for the selective extraction and preconcentration of carmine from aqueous solutions. Despite these advantageous characteristics, the application of Amberlite LA-2 for carmine extraction has not yet been systematically explored. Therefore, this study aims to develop and optimize a simple and efficient liquid–liquid extraction method based on ion-pair formation with Amberlite LA-2, enabling the quantitative determination of carmine.

2. Experimental

2. 1 Materials and Instrumentation

All chemicals used in this study were of high purity and suitable for analytical applications. Carmine (90%) was obtained from Sigma-Aldrich. The liquid ion-exchanger Amberlite LA-2 (99%) was supplied by BDH Laboratory Reagents. Dichloromethane solvent

(DCM, 99%) was purchased from Pure Chemistry, while sodium hydroxide(NaOH, 99%) was obtained as an Analytical Reagent grade chemical. Furthermore, hydrochloric acid (HCl, 37%) was acquired from Chemsolute and used as received without further purification. All solutions were prepared using distilled water. Measurements and experiments were performed using a 4-digit balance (Mettlertoledo/Al204), a pH meter (Thermo Electron /Orion3 Star)/ USA), and a UV-Vis spectrophotometer (Thermo Electron / Uv-Visible Spectrophotometer).

2.2 Solution Preparation

2.2.1 Preparation of Carmine Dye Solution

All standard carmine dye solutions were prepared from the stock solution of the dye by dissolving the required weight of the dye in a known volume of deionized water to obtain a solution with a concentration of 200 ppm. From these solutions, dye solutions were prepared at different concentrations (20, 40, 60, 80, 100, 120, 140 ppm).

2.2.2 Preparation of Amberlite LA-2 Solution

The secondary amine solution of Amberlite LA-2 (0.83 g/cm^3, 377.27g/mol) was prepared at concentrations of 0.011, 0.022, 0.044, 0.088, and 0.132 M by measuring 0.25, 0.5, 1, 2, and 3 mL of the liquid extractant, respectively, and diluting each to 50 mL using dichloromethane in a beaker or flask. The prepared solutions were transferred to tightly sealed bottles and stored until use. To study the effect of secondary amine concentration on the dye extraction process, each solution was freshly prepared before every experiment to minimize solvent loss due to the high volatility and low boiling point of dichloromethane.

2.3 Carmine Dye Extraction

Liquid–liquid extraction experiments were carried out by mixing equal volumes of aqueous and organic phases. Aliquots of 10 mL of aqueous carmine dye solutions at different concentrations (20, 40, 60, 80, 100, 120, and 140 ppm) were placed in tightly sealed bottles. Subsequently, 10 mL of Amberlite LA-2 dissolved in dichloromethane at concentrations of 0.011, 0.022, 0.044, 0.088, and 0.132 M was added.

The mixtures were shaken at 200 rpm for predetermined contact times (15, 30, 45, and 60 min) at room temperature (25 °C). After shaking, the phases were allowed to separate using a separatory funnel, and the organic (lower) phase was carefully withdrawn. An aliquot of 3 mL from the aqueous phase was collected, and its absorbance was measured at the maximum wavelength of carmine dye ($\lambda_{max} = 514$ nm) using a UV–Vis spectrophotometer.

The distribution coefficient (K_D), extraction efficiency (%E), and loading factor (Z) were calculated using standard liquid–liquid extraction equations, as given in Equations (1)–(3):

$$K_D = \frac{[Dye]_{org}}{[Dye]_{aq}} \qquad (1)$$

$$E\% = \frac{[Dye]o,aq - [Dye]aq}{[Dye]o,aq} \times 100 \qquad (2)$$

$$Z = \frac{[Dye]_{org}}{[\mathrm{R_2NH}]_0} \qquad (3)$$

where $[Dye]_{\{org\}}$ and $[Dye]_{\{aq\}}$ represent the dye concentration in the organic and aqueous phases at equilibrium, respectively, $[Dye]_{\{0,aq\}}$ is the initial dye concentration in the aqueous phase, and $[R_2NH_0]$ is the initial concentration of Amberlite LA-2 in the organic phase

2.4. Effect of pH on Extraction

The effect of pH on carmine dye extraction was investigated over a pH range of 2–9. The pH of a 60 ppm aqueous dye solution was adjusted using 0.1 N hydrochloric acid (HCl) or 0.1 N sodium hydroxide (NaOH).

For each experiment, 10 mL of Amberlite LA-2 solution (0.044 M) in dichloromethane was mixed with 10 mL of the dye solution adjusted to the desired pH. The mixtures were shaken at 200 rpm for 60 min at 25 °C. After phase separation, the residual dye concentration in the aqueous phase was determined spectrophotometrically at 514 nm.

2.5. Preparation of Lipstick and Candy Samples

2.5.1. Sample Pre-treatment and Qualitative Screening

Several commercial samples, including lipstick, jam, and candy, were examined for the presence of carmine dye. For each sample, 1.0 g was accurately weighed and dissolved in 50 mL of distilled water. The mixtures were shaken at room temperature for 5 h to ensure efficient extraction of the dye, followed by centrifugation at 1400 rpm for 10 min to obtain a clear aqueous extract.

The extracts were analyzed using a UV–Vis spectrophotometer. The presence of carmine dye was confirmed by monitoring its characteristic absorption peak at approximately 514 nm. Samples showing no significant absorption in the range of 500–600 nm were considered free of detectable carmine and excluded from further analysis. Based on this screening, jam and one candy sample showed no carmine content, while red lipstick and M&M candy samples exhibited clear absorption at 514 nm and were selected for quantitative analysis.

2.5.2. Quantitative Extraction from Real Samples

The optimized extraction conditions were applied to the selected lipstick and M&M candy samples. The initial concentration of carmine dye in each sample was estimated using the calibration curve. Aliquots of 10 mL of the aqueous extract were transferred into tightly sealed bottles, followed by the addition of 10 mL of 0.044 M Amberlite LA-2 dissolved in dichloromethane.

The mixtures were shaken at 200 rpm for 60 min to allow complete transfer of the dye into the organic phase. After separation of the phases using a separatory funnel, the absorbance of both aqueous and organic phases was measured at 514 nm. The extraction efficiency and carmine concentration in the real samples were calculated accordingly.

3. Results and Discussion

3.1 Determination of the Maximum Absorption Wavelength and Calibration Curve

The maximum absorption wavelength (λ_{max}) of the carmine dye was determined by scanning a 20 ppm aqueous solution over the wavelength range of 400–800 nm using a UV–Vis spectrophotometer. The wavelength corresponding to the highest absorbance was identified at 514 nm, as shown in Figure 2.

A series of standard carmine dye solutions were prepared from the stock solution at different concentrations (0, 20, 40, 60, 80, 100, 120, and 140 ppm). The absorbance of each solution was measured at the maximum wavelength of 514 nm using a UV–Vis spectrophotometer, as illustrated in Figure 3. A calibration curve

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was constructed by plotting absorbance versus concentration, and the resulting linear equation was used to calculate the carmine dye concentration in the aqueous phase after each extraction experiment [12, 17, 18].

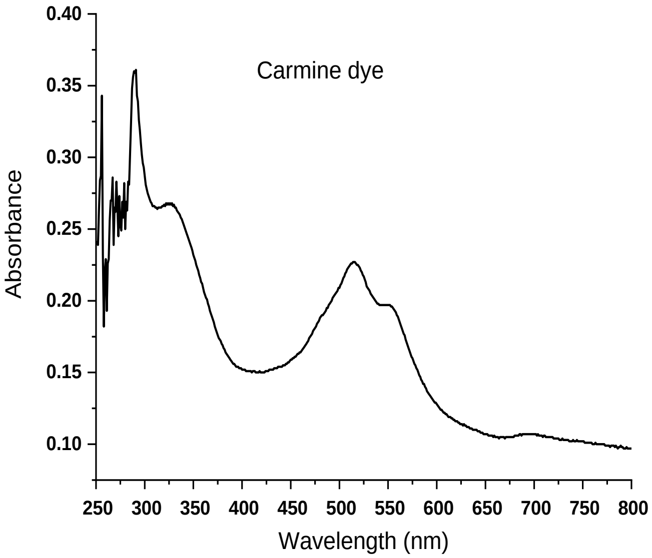
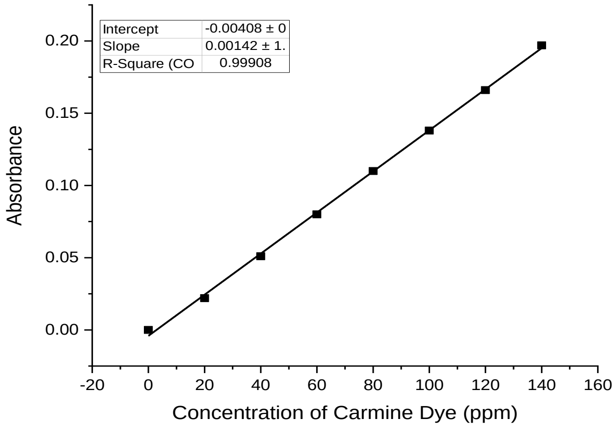


Fig. 2: Maximum Wavelength of Carmine Dye



Intercept	-0.00408 ± 0
Slope	0.00142 ± 1.
R-Square (CO	0.99908

Fig. 3: Standard calibration curve for aqueous carmine dye

3.2 Effect of initial dye concentration

The influence of the initial carmine dye concentration on the extraction efficiency was investigated by varying the dye concentration in the range of 20–140 ppm while maintaining constant experimental conditions, namely Amberlite LA-2 concentration (0.044 M), contact time (60 min), and room temperature. The obtained results are summarized in Table 1.

Table 1: Effect of initial carmine dye concentration on extraction by Amberlite LA-2

$C_{Amberlite}$ (M)	t (min)	C_{carmin} (ppm)	C_{aq} (ppm)	C_{org} (ppm)	K_D	Z (g/mol)	%E
0.044	60	20	9.357	10.643	1.137	0.24	53.214
		40	17.929	19.929	1.112	0.45	55.179
		60	25.071	34.929	1.393	0.789	58.214
		80	20.786	59.214	2.849	1.346	74.018
		100	34.357	65.643	1.911	1.482	65.643
		140	49.357	90.643	1.836	2.046	64.745

Table 1 presents the extraction behavior of carmine dye at different initial concentrations in the presence of Amberlite LA-2. At relatively low dye concentrations (20–40 ppm), a limited amount of dye was transferred to the organic phase (10.64–19.93 ppm), accompanied by low loading factor values (Z = 0.24–0.45 g/mol). This behavior can be attributed to the lower availability of dye molecules in the aqueous phase, resulting in fewer interactions with the active sites of the extractant.

As the initial dye concentration increased from 60 to 100 ppm, a significant enhancement in extraction performance was observed. The dye concentration in the organic phase increased from 34.93 to 65.64 ppm, while the loading factor rose from 0.789 to 1.482 g/mol. This improvement indicates more efficient utilization of the available extraction sites due to increased dye–extractant interactions at higher dye concentrations.[13 ،12]

At the highest investigated dye concentration (140 ppm), the amount of dye extracted into the organic phase reached 90.64 ppm, and the loading factor attained a maximum value of 2.046 g/mol. This result reflects the ability of Amberlite LA-2 to accommodate higher quantities of dye at elevated concentrations. Overall, the data demonstrate a direct relationship between the initial dye concentration and the extraction capacity of the extractant [14, 19].

The variation of extraction efficiency (E%) and distribution coefficient (KD) as a function of the initial dye concentration is illustrated in Figure 4. Both E% and KD increased progressively with increasing dye concentration up to 80 ppm, indicating that the extractant had not yet reached saturation. Beyond this concentration, a slight decrease in both parameters was observed, suggesting partial saturation of the available binding sites on Amberlite LA-2.

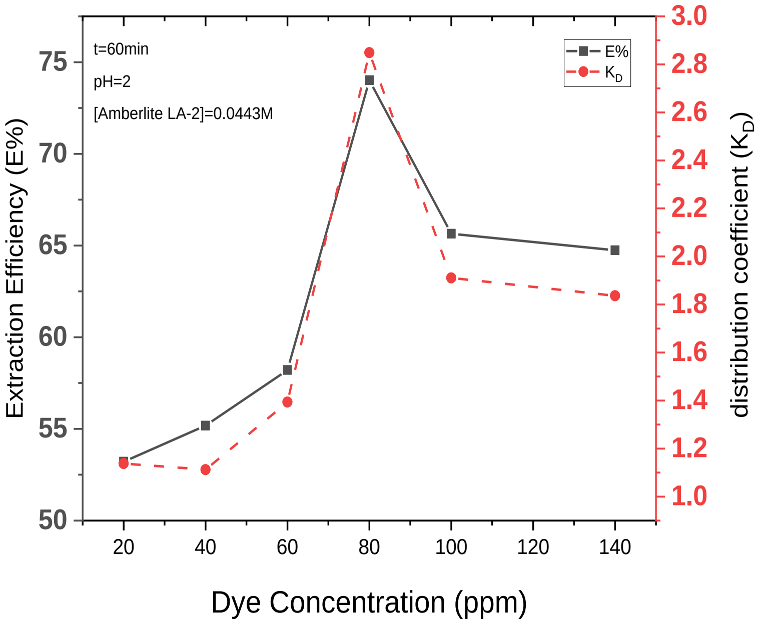


Fig. 4: Effect of initial concentration of carmine dye

3.3 Effect of Amberlite LA-2 concentration on extraction

The effect of Amberlite LA-2 concentration on the extraction of carmine dye was investigated to evaluate the role of the extractant in the liquid–liquid extraction process. The experiments were carried out at a fixed initial dye concentration of 80 ppm and a constant contact time of 60 min. The obtained results are summarized in Table 2 and illustrated in Fig. 5.

Table 2: Effect of Amberlite LA-2 concentration on the extraction efficiency and distribution of carmine dye

C_{carmin} (ppm)	t (min)	$C_{Amberlite}$ (M)	C_{aq} (ppm)	C_{org} (ppm)	K_D	Z (g/mol)	%E
80	60	0.011	55.071	24.929	0.453	2.266	31.161
		0.022	33.929	46.071	1.358	2.094	57.589
		0.044	20.786	59.214	2.849	1.346	74.018
		0.088	40.071	39.929	0.996	0.454	49.911
		0.132	52.929	27.071	0.511	0.205	33.839

Table 2 presents the influence of Amberlite LA-2 concentration on the distribution of carmine dye between the aqueous and organic phases. At a low extractant concentration of 0.011 M, a large fraction of the dye remained in the aqueous phase (Caq = 55.071 ppm), while only a limited amount was transferred to the organic phase (Corg = 24.929 ppm), resulting in a low extraction efficiency (E% = 31.161) and distribution coefficient (KD = 0.453).As the Amberlite concentration increased to 0.044 M, a significant improvement in extraction performance was observed. The concentration of dye in the organic phase increased to 59.214 ppm, while the residual concentration in the aqueous phase decreased to 20.786 ppm. Under these conditions, the highest extraction efficiency (E% = 74.018) and distribution coefficient (KD = 2.849) were achieved, indicating the availability of sufficient active sites on the extractant for effective dye uptake. However, further increasing the Amberlite concentration beyond 0.044 M led to a noticeable decline in extraction efficiency. At 0.132 M, the amount of dye transferred to the organic phase decreased to 27.071 ppm, accompanied by a reduction in KD (0.511) and loading factor (Z = 0.205 g/mol). This behavior can be attributed to the saturation of active sites and possible aggregation or steric effects within the organic phase, which limit the effective interaction between the dye molecules and the extractant. Overall, the results demonstrate that both the extraction efficiency (E%) and distribution coefficient (KD) increase with increasing Amberlite LA-2 concentration up to an optimum value of 0.044 M. Beyond this concentration, a gradual decrease in extraction performance is observed, indicating that an excess amount of extractant does not enhance dye extraction and may even hinder the process. These trends are clearly illustrated in Fig. 5

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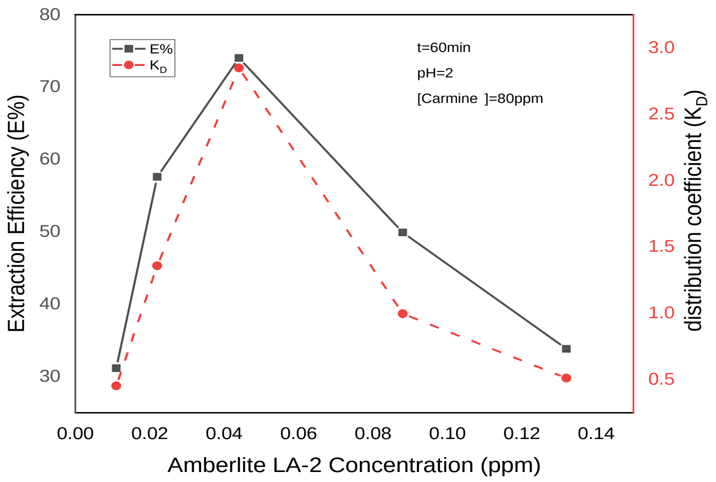

Fig. 5: Effect of initial concentration of Amberlite LA-2

3.4 Effect of pH on Extraction

The effect of pH on the extraction of carmine dye from the aqueous phase into the organic phase containing Amberlite LA-2 was investigated over a pH range of 2–9 at a fixed initial dye concentration of 80 ppm. All experiments were carried out at room temperature (25 °C) with a shaking speed of 200 rpm for 60 minutes. The obtained results are summarized in Table 3 and illustrated in Figure 6.

he results demonstrate that Amberlite LA-2 exhibits high extraction efficiency for carmine dye within a narrow acidic pH range. The pH of the aqueous solution plays a critical role in the extraction process, as it influences both the ionization state of the carmine dye and the interaction mechanism between the dye molecules and the functional groups of Amberlite LA-2 [20, 21].

Table 3 shows the effect of pH on carmine dye extraction using Amberlite LA-2 at a concentration of 0.044 M, a contact time of 60 minutes, and an initial dye concentration of 80 ppm. At pH = 2, the highest extraction performance was achieved, where the dye concentration in the organic phase (C_{org}) reached 59.214 ppm, the loading capacity (Z) was 1.346 g/mol, and the extraction efficiency (E%) reached 74.018%, which represents the maximum value among all investigated pH conditions.

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Table 3: Extraction of carmine dye by Amberlite under the influence of pH

$C_{Amberlite}$ (M)	C_{carmin} (ppm)	t (min)	pH	C_{aq} (ppm)	C_{org} (ppm)	K_D	Z (g/mol)	%E
0.044	80	60	2	20.78571	59.214	2.849	1.346	74.018
			3	33.643	46.357	1.378	1.054	57.946
			4	37.929	42.071	1.109	0.956	52.589
			5	48.643	31.357	0.645	0.713	39.196
			6	48.643	31.357	0.645	0.713	39.196
			7	50.786	29.214	0.575	0.664	36.518
			8	52.929	27.071	0.511	0.615	33.839
			9	57.214	22.786	0.398	0.518	28.482

As the pH increased gradually from 2 to 9, a clear decline in extraction performance was observed. The amount of dye transferred to the organic phase (C_{org}) decreased from 59.214 to 22.786 ppm, accompanied by a reduction in loading capacity (Z) from 1.346 to 0.518 g/mol and a decrease in the distribution coefficient (K_D) from 2.849 to 0.398. Consequently, the extraction efficiency (E%) decreased significantly from 74.018% at pH = 2 to 28.482% at pH = 9.

The enhanced extraction efficiency under acidic conditions can be attributed to the increased protonation of the secondary amine groups of Amberlite LA-2, which promotes stronger electrostatic interactions and ion-pair formation with the anionic carmine dye. In contrast, at higher pH values, the degree of protonation decreases, weakening the interaction between the dye molecules and the extractant, and resulting in lower extraction efficiency and loading capacity.

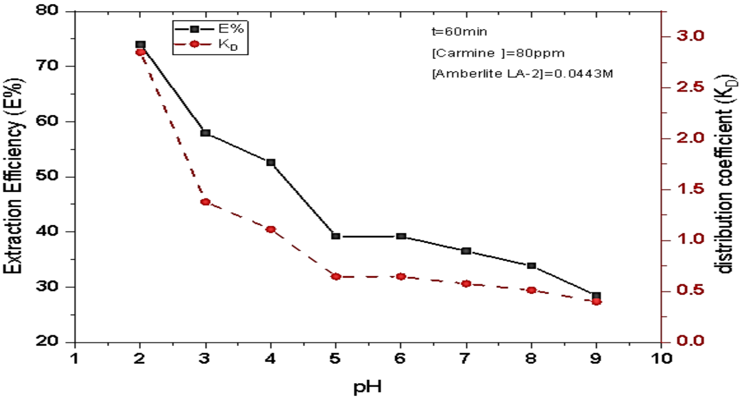

Fig. 6: Effect of pH on the carmine extraction process

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3.5 Effect of contact time

The influence of contact time on the extraction efficiency of carmine dye by Amberlite LA-2 was investigated at different time intervals (15, 30, 45, 60, 90, 120, 150, and 180 minutes), using a dye concentration of 80 ppm, at room temperature (25°C) and a shaking speed of 200 rpm. The obtained results are summarized in Table 4.

Table 4: Extraction of carmine dye by Amberlite under the influence of contact time

$C_{Amberlite}$ (M)	C_{carmin} (ppm)	t (min)	C_{aq} (ppm)	C_{org} (ppm)	K_D	Z (g/mol)	%E
0.044	80	15	32.929	47.071	1.429	1.063	58.839
		30	26.5	53.5	2.019	1.208	66.875
		60	20.786	59.214	2.849	1.346	74.018
		90	32.214	47.786	1.483	1.079	59.733
		120	46.5	33.5	0.728	0.756	41.875
		150	51.5	28.5	0.553	0.643	35.625
		180	54.357	25.643	0.472	0.579	32.054

As shown in Table 4, the amount of dye transferred to the organic phase increases with increasing contact time, reaching a maximum at 60 minutes (C_{org} = 59.214 ppm, Z = 1.346 g/mol, E% = 74.018%). Longer contact times beyond 60 minutes lead to a decrease in both the dye concentration in the organic phase and extraction efficiency, likely due to the re-equilibration of the dye between the aqueous and organic phases. These results indicate that 60 minutes is the optimal contact time to achieve maximum extraction efficiency for carmine dye under the applied conditions

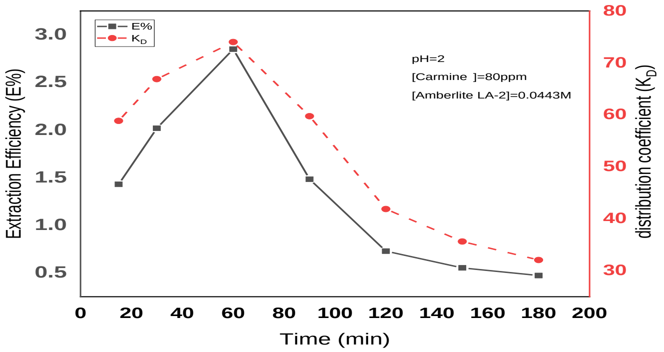

Fig. **7:** Effect of contact time on the extraction process of carmine dye

3.6 Dye extraction and Extraction mechanism

In this study, significant extraction of carmine dye by Amberlite LA-2 was achieved, and the extraction mechanism can be summarized as follows (Figure 8):

1. Ionization of Carmine Dye: Carmine dye dissolves in the aqueous phase, where the acidic carboxyl group ionizes, producing the dye in the form of a negatively charged anion. The presence of eight phenolic hydroxyl groups enhances the solubility of carmine dye, as shown in Equation (1):

$$\text{R-COOH} + H_2O \rightarrow \text{R-COO}^- + H^+ \qquad (1)$$

2. Formation of Ion-Pair Complex: The anionic carmine dye interacts electrostatically with the cationic form of Amberlite LA-2 ($R_2NH_2^+$), forming a stable ion-pair complex, as shown in Equation (2):

$$R_2NH_2^+ + \text{R-COO}^- \rightarrow [R_2NH_2][\text{OOSR}] \qquad (2)$$

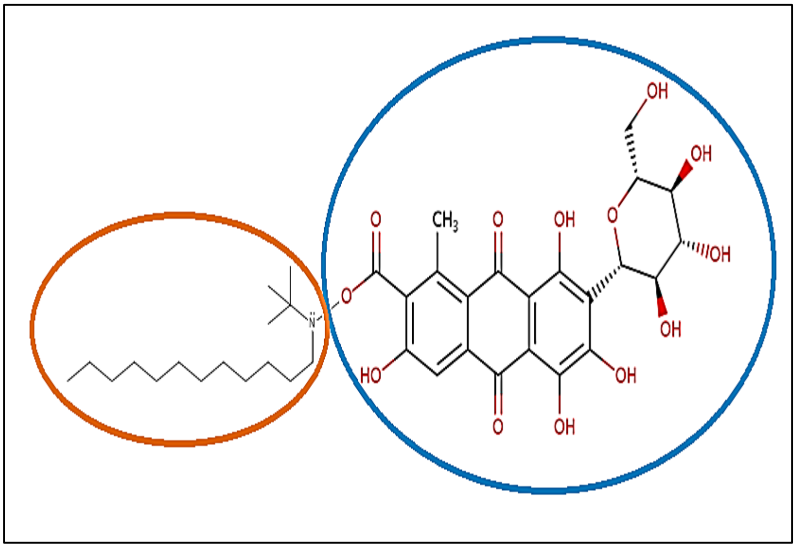

Fig. 8: Electrostatic attraction between the Amberlite cation and the dye anion

This reaction facilitates the transfer of carmine dye from the aqueous phase to the organic phase.

Effect of Acidity (pH): The pH of the medium plays a crucial role. A narrowly acidic environment promotes complete ionization of the carboxyl group, enhancing electrostatic interaction with Amberlite LA-2 and resulting in maximum extraction efficiency. Additionally, carmine

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exhibits partial solubility in dichloromethane (DCM), the solvent used for dissolving the amine. Higher acid concentrations in the organic layer increase dye solubility, while DCM acts as an effective carrier, facilitating the transfer of the ion-pair complex $[R_2NH_2]^+[Dye]^-$ from the aqueous to the organic phase [22].

3.7 Application

3.7.1 Detection of the presence of carmine dye in the tested materials

Food samples including strawberry jam, M&M candy, and commercial lipstick were analyzed. The UV-Vis spectra of their aqueous extracts were recorded to identify the presence of carmine dye by detecting the characteristic maximum absorption at λ_{max} = 514 nm.

- Strawberry jam and lollipop samples showed no absorption in the 500–600 nm range, indicating the absence of carmine dye.
- M&M candy and lipstick samples exhibited maximum absorption at 514 nm, confirming the presence of carmine dye (Figure 9).

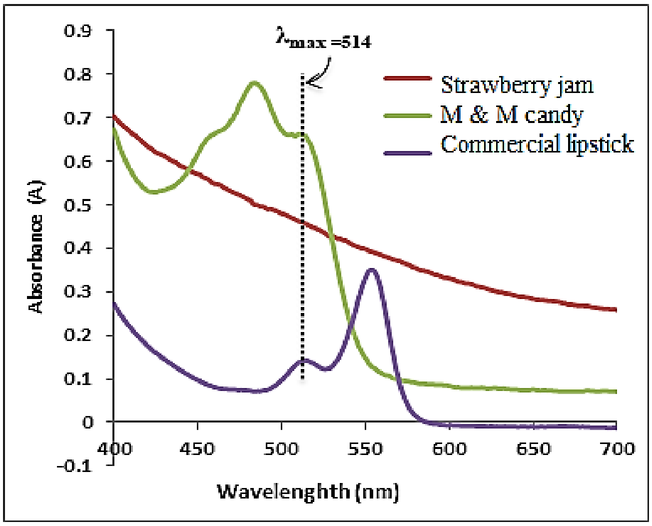

Fig. 9: Detection of the presence of carmine dye in the tested materials

3.7.2 Extraction of carmine dye from the tested samples using Amberlite LA-2

The optimized extraction procedure was applied to the positive samples (M&M candy and lipstick). The results are summarized in Table 5 and Figure 9.

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- The total carmine concentration in lipstick was lower than in candy gum. Consequently, the distribution coefficient (KD) and extraction efficiency (E%) were higher for lipstick than for candy gum.
- In lipstick, carmine dye concentration was higher in the organic phase and lower in the aqueous phase, while in candy gum, the dye was more evenly distributed between both phases.

Table 5: Extraction of carmine dye from some industrial products using Amberlite

Sample.	$C_{Amberlite}$ (M)	t (min)	C_{aq}	C_{org}	C_{total}	K_D	E%
lipstick	0.044	60	27.929	112.929	140.858	4.0434	80.17
m&m candy	0.044	60	96.5	89.357	185.857	0.926	48.08

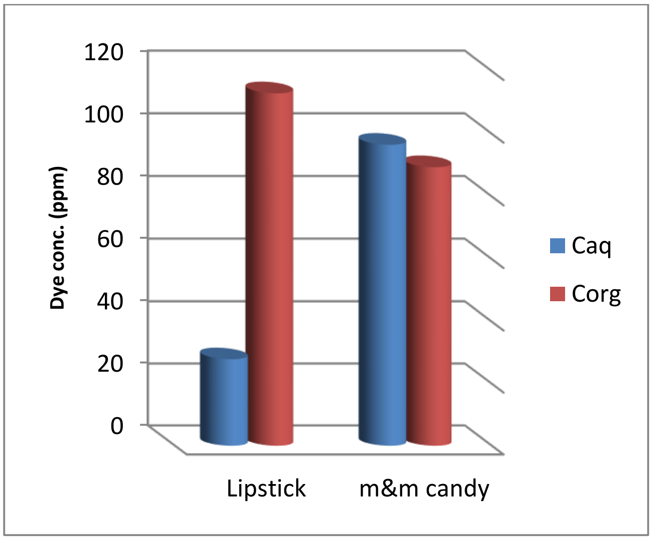

Fig.10: Concentration of carmine dye in aqueous and organic

Media

The differences in extraction efficiency are attributed to the sample matrix. Lipstick, containing oily and hydrophobic components, favors transfer of carmine to the organic phase, resulting in higher KD and E%. Conversely, candy gum, rich in sugars and water-

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soluble additives, retains more dye in the aqueous phase, lowering extraction efficiency.

4. Conclusion

This study demonstrates a simple and efficient method for monitoring carmine dye, offering an alternative to complex and costly chromatographic techniques. The extraction process using Amberlite LA-2 operates under mild, easily controllable, and low-cost conditions. The results show that Amberlite LA-2 is an effective liquid resin for the extraction of carmine (E120) from both aqueous solutions and food or cosmetic products.

Optimal extraction and distribution efficiencies were achieved under the following conditions: an amine concentration of 0.044 M, a contact time of 60 minutes, and an acidic medium at pH ≈ 2. The study also revealed that increasing the carmine concentration enhances extraction until the resin’s active sites become saturated. The acidic medium was found to play a crucial role in promoting electrostatic interactions between carmine molecules and Amberlite LA-2.

Finally, practical application to real samples of sweets and lipstick confirmed the method’s capability for both quantitative and qualitative detection of carmine at λmax= 514 nm, demonstrating that Amberlite LA-2, as an ion-exchanger, can be effectively used to remove carmine dye from aqueous solutions.

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Conflict of Interest

The authors state that they have no interest conflicts.

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