al Kimiya: Jurnal Ilmu Kimia dan Terapan,
p-ISSN: 2407-1897, e-ISSN: 2407-1927
Vol. 11, No. 1 (84-94), June 2024/Djulhijah 1445

PEEL-OFF MASK FORMULATION FOR FACIAL SKIN PROTECTION MADE FROM ACTIVE CARBON QUANTUM DOTS FROM RICE WASHING WATER

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Article Information

Received: Apr 6, 2024
Revised: May 31, 2024
Accepted: Jun 15, 2024
Published: Jun 29, 2024

DOI: 10.15575/ak.v11i1.36475

Keywords:
Cosmetics, CQDs, UV blocking, peel-off mask formulation.

Abstract

Excessive exposure to ultraviolet (UV) rays can damage facial skin. Carbon Quantum Dots (CQDs) are active ingredients that can be formulated into peel-off masks needed to protect facial skin from UV exposure. This research aims to formulate a peel-off mask as facial skin protection made from the active ingredient CQDs from rice washing water, test the characteristics, and determine user responses to the product. The mask formulation is divided into five versions, namely F0 (without CQDs), F1, F2, and F3 (with CQDs added at concentrations of 2%, 4%, and 6%, respectively), and F+ (with added vitamin C). The resulting formulations were tested through physical tests, fluorescence using a UV lamp, and UV blocking tests. The test results for the five mask formulas showed a pH range of 4.5-5.6, stability over three weeks of storage, drying time within 27-30 minutes, homogeneity, viscosity ranging from 12,810-18,430 cPs, and spreadability ranging from 5.4-6.6 cm. The results of the organoleptic test using the one-way ANOVA test show that variations in mask formulas do not have a significantly effect on preferences for color, smell, texture, and general preferences. The results of the fluorescence test showed that there was luminescence in formulas F1, F2, and F3. UV blocking properties in the wavelength range 290-320 nm are shown in the formulas F1, F2, F3, and F+. Based on these tests, it can be concluded that the peel-off mask formulation with CQDs from rice wash water successfully produced a good peel-off mask product with a high SPF value, especially in formula F3.

INTRODUCTION

Facial skin is one part of the body that requires special care to maintain its health. Most people, especially women, want healthy, bright, and white facial skin [1]. However, ultraviolet (UV) rays have been known to cause various negative effects on facial skin [2].

UV light is divided into three types, namely A, B, and C with wavelengths of 320-400 nm, 290-320 nm, and 200-290 nm respectively [2]. UV-C rays have the shortest wavelength so the rays do not reach the earth. UV-A and UV-B rays which have higher wavelengths can cause skin disorders such as erythema, edema, hyperpigmentation, and more dangerously cause skin cancer [3]. One effort that can be made is to reduce the absorption of UV rays through blocking activities that limit these rays [4].

One form of cosmetics commonly used by women is facial masks [5]. Facial mask cosmetic products can be one way to overcome problems that arise in the facial skin area [6]. As time goes by, innovation in facial masks is needed that can minimize the negative effects of using masks, such as powder masks, creams, and peel-offs [7]. A peel-off gel mask is a mask in the form of a gel that is applied to the skin and over a certain period of time forms an elastic, transparent film layer, and after drying the mask can be removed immediately without needing to be rinsed with water [8].

The use of active ingredients is needed in cosmetics to help provide maximum results for users in the long term [9]. One of the active materials that is currently developing rapidly is carbon quantum dots (CQDs). CQDs are nanocarbons that have a size smaller than 10 nm [10]. CQDs have advantages including good biocompatibility, photostability, easily soluble in water, non-toxic, easy to carry out synthesis methods, and can be produced from organic materials that are abundant in nature [11].

Rice washing water is an organic material that is abundant in nature but is considered a useless waste. Rice-washing water waste has good nutrition for facial skin because it can be used as a treatment to brighten the skin and ward off skin damage caused by sunlight. Rice washing water contains several ingredients such as vitamin B,

minerals, and vitamin E which are beneficial for skin health [12]. Due to its many contents and benefits, rice washing water can be synthesized into active ingredients in the form of CQDs which influence the performance of masks.

Based on the description above, this research focuses on peel-off mask formulations that use the active ingredient CQDs. The research aims to formulate a peel-off mask for facial skin protection using the active ingredient CQDs from rice washing water, test the characteristics, and determine user responses to the product. This test was carried out to evaluate the quality of the masks produced.

EXPERIMENT

The research was conducted at the Chemistry Education Laboratory, Faculty of Teacher Training and Education, and the Physics Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Syiah Kuala University. This research will take place from January to March 2024.

Material

The chemicals used are CQDs from rice washing water, aquabidest, 96% ethanol, glycerin, PVA, CMC, methylparaben, TEA, vitamin C, filter paper, and graph paper.

Instrumentation

The tools used in this research are analytical scales, hot plates, measuring pipettes, suction balls, spatulas, measuring cups, measuring flasks, glass funnels, dropper pipettes, petri dishes, evaporating dishes, glass plates, watch glasses, stirring rods, beakers, cuvettes, test tubes, test tube racks, ovens, UV-VIS spectrophotometers, digital soil pH meters, thermometers, Brookfield viscometers, vials, urine pots, weighing weights, statives, and clamps, Gravindo/GX-L1250 UV lamps, hairdryer, tweezers and stopwatch.

Procedure

Preparation of CQDs

The CQDs synthesized from rice washing water used in the research were tested for their luminescence ability to determine their quality [13]. The testing process is carried out by preparing CQDs and then placing them in a test tube. The prepared CQDs were then irradiated under the Gravindo/GX-L1250 UV lamp.

Mask Formulation

The formulation of the peel-off gel mask requires basic raw materials, namely PVA, glycerin, TEA, CMC, methylparaben, aquabidest [14][15]. Apart from the basic raw materials, this formulation also uses additional raw materials in the form of CQDs from rice washing water and vitamin C. The mask formulation goes through several stages, first, PVA is added to cup A, sufficient aquabidest is added and heated using a hotplate at 80℃ until it expands completely and stirred to make it homogeneous [15]. Second, in cup B, dissolve CMC in cold aquabidest until it swells completely. Third, in cup C glycerin and methylparaben are dissolved in hot aquabidest. Fourth, in cup D, add the ingredients from cups A, B, and C, add TEA successively, and stir until homogeneous. Fifth, CQDs from rice washing water were included in several formulas and vitamin C was added to other formulas as a positive control and stirred until homogeneous. The mask formulation can be seen in the following **Table 1**.

Table 1. Mask Formulation

Composition (%)	Formulas Combination (%)				
	F0	F1	F2	F3	F+
CQDs from rice washing water	0	2	4	6	0
PVA	10	10	10	10	10
Vitamin C	0	0	0	0	1
CMC	1	1	1	1	1
Glycerin	10	10	10	10	10
TEA	2	2	2	2	2
Metyl paraben	0.2	0.2	0.2	0.2	0.2

The mask preparations were tested including physical tests (pH test, storage stability, dry time, homogeneity, viscosity, spreadability, and organoleptic), fluorescence test using a UV lamp and UV blocking test.

pH Test

The pH test is carried out by placing the preparation into a test tube and measuring the pH value using a soil tester which is dipped directly into it [16].

Storage Stability Tests

Storage stability tests were carried out on mask preparations in containers and then their stability was tested by observing the pH value, odor, and color periodically for 3 weeks with routine control once every week [17]. Storage stability tests begin on February 13, 20, and 27 2024.

Dry Time Test

The dry time test was carried out by preparing a mask preparation of 0.3 g and applying it to the surface of the skin of the hand with a size of 3 x 3 cm. After that, let it sit until it dries, and the drying time is measured using a stopwatch [15].

Homogeneity Test

Homogeneity testing is carried out by placing or smearing the preparation on a glass object. The preparation was observed for any visible coarse particles or inhomogeneities [18].

Viscosity Test

The viscosity test stages were carried out using a Brookfield viscosity apparatus. The spindle, which is one of the components of the Brookfield device, is then dipped directly into the prepared gel mask preparation. After that, the viscosity value of the mask preparation being tested will be obtained [19].

Spreadability Test

The spreadability test was carried out by preparing a gel preparation weighing 0.5 g. The preparation is placed in the middle of a glass plate, then charged on top of another glass plate and weights of up to 50, 100, 150 and 200 g are added. After that, it was left for 1 minute and the diameter of the spread was recorded [20].

Organoleptic Test

The test stages were carried out involving five panelists, starting with all panelists applying a peel-off mask to the surface of the skin of their hands. After that, the panelists were asked to provide an assessment of the aspects of color, smell, texture, and general preferences of the mask preparation [20].

Fluorescence Test Using a UV Lamp

The fluorescence test was carried out using samples in the form of gel masks and dried mask samples. The gel-shaped samples in the container and the dried mask samples were observed under the Gravindo/GX-L1250 UV lamp [21].

UV Blocking Test

The UV blocking test stages were carried out by preparing a sample of 0.1 g, then dissolving it in 25 mL of aquabidest and stirring until homogeneous. The dissolved solution is then filtered and put into a cuvette to the limit mark to create a test absorption curve. Samples were tested using a wavelength of 290-320 nm with intervals of 5 nm (**Table 2**) [22]. Testing involves using aquabidest as a blank.

The test results in absorbance values are then recorded and the sun protection factor (SPF) value can be calculated for the sample using the following equation [22].

$$SPF = CF \times \sum_{320}^{290} EE\ (\lambda_{290\text{-}320}) \times I\ (\lambda_{290\text{-}320}) \times Absorbance\ (\lambda_{290\text{-}320}) \quad (1)$$

Information:
EE : spectrum of erythema effects
I : light intensity spectrum
CF : correlation factor (value 10)

Table 2. EE x I values at wavelengths 290-320 nm.

Wavelength	EE x I
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180
Total	1

RESULT AND DISCUSSION

Peel-off masks are a cosmetic that has many advantages compared to other types of masks. CQDs are one of the active ingredients that can be formulated into cosmetics such as peel-off masks. CQDs synthesized from rice washing water which will be formulated into good quality peel-off masks are characterized by a bluish green glow when illuminated with a UV lamp. CQDs have fluorescent properties at room temperature when excited with UV light (**Figure 1**) [13].

Figure 1. CQDs observed under UV light.

The peel-off gel mask is formulated into five versions, including F0, F1, F2, F3, and F+ (**Figure 2**). Formula F0 acts as a negative control and does not contain CQDs or vitamin C. Formulas F1, F2, and F3 contain CQDs in respective concentrations, namely 2%, 4% and 6% and formula F+ as a positive control contains the addition of vitamin C. Addition vitamin C because have a similar role as CQDs, being able to protect the skin from exposure to UV light.

(a) (b) (c) (d) (e)

Figure 2. Colors of 5 peel-off mask formulas under visible light (a) Formula F0 (without adding active ingredients); (b) Formula F1 (2% CQDs); (c) Formula F2 (4% CQDs); (d) Formula F3 (6% CQDs); (e) Formula F+ (1% vitamin C).

pH Test

pH testing on mask preparations was carried out at room temperature and produced pH values ranging from 4.5 to 5.6 for the five mask formulas. The pH value of the mask must match the skin's pH, namely close to 4.5 to 6.5 4.[19]. If the mask has a pH value that is too alkaline it will result in scaly skin, whereas if it has a pH value that is too acidic it will cause the skin to become irritated [23]. The pH test results can be seen in **Figure 3**.

The test results in the picture show that the higher the concentration of active ingredients used in the formula, the lower the pH value of the formula. This is due to the influence of the active ingredients in the form of CQDs. Based on the pH test carried out, it showed that the CQDs used have a relatively low pH value, namely 5.3. The increasing concentration level of the active ingredient will result in a lower pH value due to the influence of the acid content in the active ingredient [24].

The addition of CQDs active ingredients to F1, F2, and F3 produces higher pH values than F0. This is due to the interaction between the compositions in the mask which affects changes in the pH value during the test, resulting in F0 experiencing a drastic decrease in pH. Mask products F1, F2, and F3 contain CQDs which are not sensitive to changes in pH [13], which means they can act as a pH buffer so that there is no drastic decrease in pH due to composition interactions such as in the F0 formula.

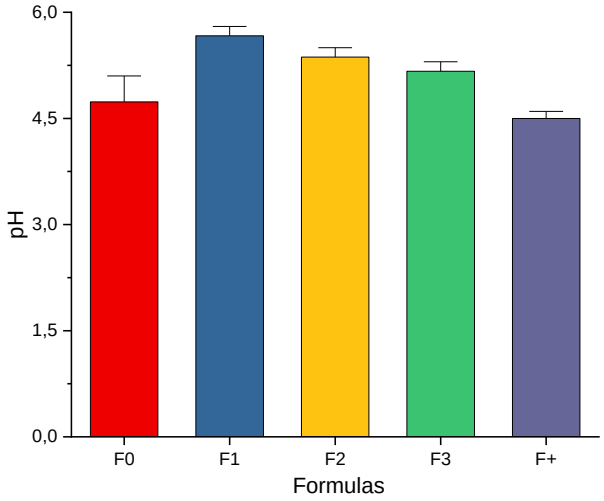

Figure 3. pH values of 5 peel-off mask formulas made from CQDs as active ingredients.

Storage Stability Tests

The results of the storage stability test showed that in the F0, F1, F2, F3, and F+ formulas there were several changes in the aspects of odor, texture, pH value, and color. However, some results show stability in several of these parameters. The results of the stability test which includes the pH aspect can be seen in **Figure 4**.

The test results in **Figure 4** show that there was a change in pH reduction in formulas F0, F1, F2, and F+ as well as a stable pH in formula F3. Changes in pH can occur due to several factors, such as light, temperature, air humidity, and environmental conditions in the storage area [25].

Apart from that, a decrease in pH can occur due to the inconstant stirring process and the influence of the storage room temperature [18]. The results of the stability test which include aspects of color, odor, and texture can be seen in **Table 3**.

The F0 formula is stable in color, odor, and texture after being controlled for 3 weeks. The color of F0 is caused by the absence of added active ingredients in the formula. Tests show that formulas F1, F2, and F3 produce a distinctive odor. Generally, the mask formula will have a distinctive odor from the increasingly dominant active ingredients [8].

The test results showed a color change in the F+ formula containing vitamin C after storage. This is because the ascorbic acid used easily reacts with CO_2 so that it turns into dehydroascorbic acid [26]. In addition, the use of vitamin C can result in mild adverse reactions and oxidative changes that cause discoloration or yellow staining [27]. The color change in the F+ formulation indicates a reaction that can occur between vitamin C and the environment, so good monitoring of its storage is required.

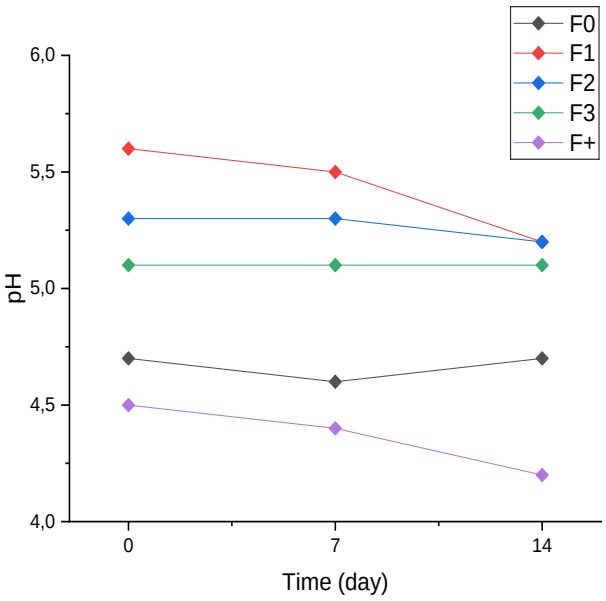

Figure 4. pH value in storage stability test of peel off mask made from CQDs active ingredients.

Table 3. Storage stability test results of peel-off masks made from active CQDs.

Aspect	Week	Formulas				
		F0	F1	F2	F3	F+
Color	1	Clear white	Yellowish white	Yellowish white	Yellow	Clear white
	2	Clear white	Yellowish white	Yellowish white	Yellow	Yellowish white
	3	Clear white	Yellowish white	Yellowish white	Yellow	Yellow
Smell	1	Odorless	Distinctive smell	Distinctive smell	Distinctive smell	Odorless
	2	Odorless	Distinctive smell	Distinctive smell	Distinctive smell	Odorless
	3	Odorless	Distinctive smell	Distinctive smell	Distinctive smell	Odorless
Texture	1	Gel	Gel	Gel	Gel	Gel
	2	Gel	Gel	Gel	Gel	Gel
	3	Gel	Gel	Gel	Gel	Gel

Dry Time Test

The dry time test results show that the five mask formulas dry at different times, namely in the range of 27-30 minutes. A good dry time for a mask ranges from 15-30 minutes [28]. This shows that the preparation tested was within a good dry time range. The dry-time test results are shown in **Figure 5.**

The test results in the picture show that the F0 formula takes the longest time for the mask to dry completely. This is because the water content in the F0 formula is more than other formulas that use CQDs and vitamin C. Generally, the water content in each formula will affect the length of time it takes for the preparation to dry [8].

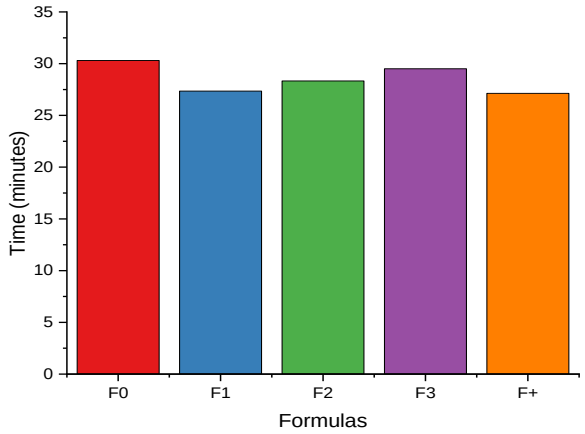

Figure 5. Dry time test results for peel-off masks made from CQDs as active ingredients.

Homogeneity Test

The homogeneity test results show that all mask formulas are homogeneous. This is because there are no visible coarse particles after observing the preparation. Homogeneity in the preparation reflects that the ingredients used in the mask formula have been mixed evenly, both in the active ingredients and additional ingredients in the entire preparation [29]. The test results can be seen in **Figure 6**.

Viscosity Test

The test results of mask preparations in formulas F0, F1, F2, F3, and F+ show different viscosity values. The test results on the entire mask formula show that the viscosity value meets the standards because it is still within the specified range. The characteristics of a good mask are masks that have a viscosity value in the range of 5000-50,000 cPs [28]. A good mask product has a consistency that is neither too thick nor too runny. This is because a mask that is too thick will be difficult to apply evenly, whereas a mask that is too liquid will easily disappear when applied [30]. The viscosity test results obtained can be seen in **Table 4**.

(a) (b) (c) (d) (e)

Figure 6. Homogeneity test results for peel-off masks made from CQDs active ingredients (a) Formula F0 (without adding active ingredients); (b) Formula F1 (2% CQDs); (c) Formula F2 (4% CQDs); (d) Formula F3 (6% CQDs); (e) Formula F+ (1% vitamin C).

Table 4. Viscosity test results of peel-off masks made from CQDs as active ingredients.

Formulas	Viscosity (cPs)
F0	18.430
F1	15.790
F2	12.810
F3	16.270
F+	17.430

Spreadability Test

The results of the spreading power test show that the gradual addition of load on the mask preparation increases the spreading distance. The F0, F1, F2, F3, and F+ formulas tested had different spreading distances. The spreadability test results ranged from 5-6 cm, which proves that all formulas have a good level of spreadability. A good dispersion distance for a mask is in the range of 5-7 cm [28]. The spreadability test results are shown in **Figure 7**.

Organoleptic Test

Organoleptic tests describe how color, smell, texture, and general liking influence the panelists' assessments. The organoleptic test results are shown in **Table 5** and **Figure 8**.
Overall, the F2 formula has the highest level of assessment. This shows that the F2 formula is the most popular formula among panelists because generally, panelists will choose the preparation that has the best color, odor and texture [31]. The organoleptic test results were analyzed using a one-way ANOVA test showing that the variations in the

formula had no real effect on the panelists' level of preference.

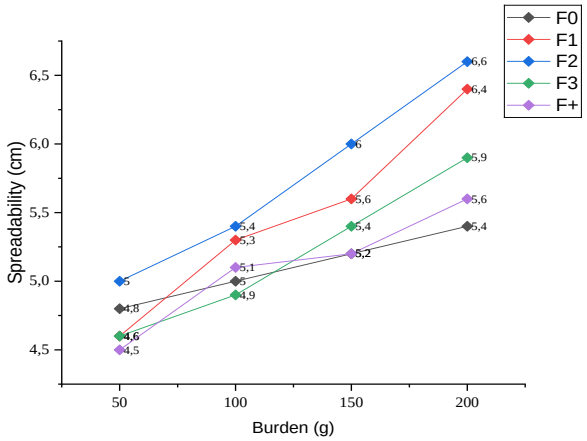

Figure 7. Test results for the spreadability of a peel-off mask made from CQDs as an active ingredient.

Table 5. Organoleptic test results of peel-off masks made from CQDs as active ingredients.

Aspect	Formulas			
	F1	F2	F3	F+
Color	4.2	4.0	3.4	4.0
Smell	3.6	4.2	3.2	3.2
Texture	3.4	4.2	3.2	4.4
General favorite	3.4	4.6	3.2	3.6

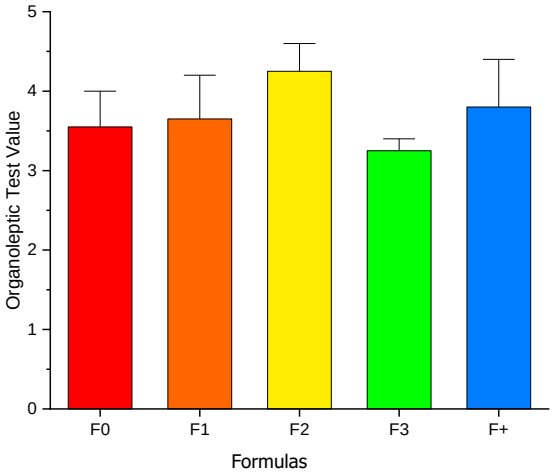

Figure 8. Organoleptic test results of peel-off masks made from CQDs as active ingredients.

Fluorescence Test Using a UV Lamp

The results of the fluorescence test in this study showed that there was luminescence in preparations containing CQDs, namely formulas F1, F2, and F3. This fluorescence test is carried out by utilizing light in the process of analyzing the characteristics of the preparation. The test results can be seen in **Figure 9** and **Figure 10**.

(a) (b) (c) (d) (e)

Figure 9. Peel-off mask preparations containing the active ingredient CQDs in gel form observed under a UV lamp (a) Formula F0 (without the addition of active ingredients); (b) Formula F1 (2% CQDs); (c) Formula F2 (4% CQDs); (d) Formula F3 (6% CQDs); (e) Formula F+ (1% vitamin C).

(a) (b) (c) (d) (e)

Figure 10. Peel-off mask preparations containing the active ingredient CQDs in dry form observed under a UV lamp (a) Formula F0 (without the addition of active ingredients); (b) Formula F1 (2% CQDs); (c) Formula F2 (4% CQDs); (d) Formula F3 (6% CQDs); (e) Formula F+ (1% vitamin C).

Formulas F1, F2, and F3 which contain active ingredients in the form of CQDs show luminescence. CQDs can emit full fluorescence in the form of colors ranging from blue to white light under UV light which describes fluorescence emission [32]. Apart from that, the luminescence produced is also caused by combining the active ingredients of CQDs with PVA [32].

UV Blocking Test

The UV blocking test results are shown in the SPF values of the five mask formulas. The results of testing the SPF values of the five mask formulas show that the F3 formula containing 6% CQDs has the highest SPF value.

Table 6. Test results for the SPF value of peel-off masks made from CQDs as active ingredients.

Formulas	SPF	Protection
F0	2.900	Minimum
F1	8.383	Maximum
F2	8.958	Maximum
F3	11.612	Maximum
F+	8.088	Maximum

The test results show that the F3 formula which contains the highest active ingredients has the highest SPF value and the F0 formula has the lowest SPF value. This illustrates that the F3 formula is the most effective in UV-blocking activity. This is because the higher the SPF value and active ingredients in preparation, the more effective the preparation will be in UV-blocking activity [33]. The absorbance value of the peel-off mask can be seen in **Figure 11**.

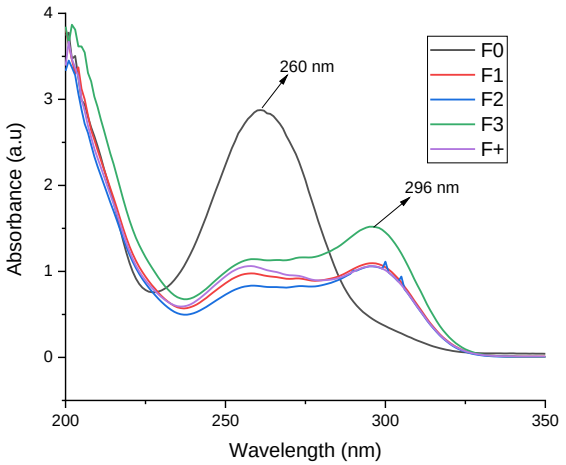

Figure 11. The absorbance value of a peel-off mask made from CQDs as an active ingredient.

The test results in the image show that there is UV light absorption in the five mask formulas. The F0 formula which does not contain active ingredients absorbs UV rays in the wavelength range 227-320 nm. This absorption is in the UV-C (200-290 nm) and UV-B (290-320 nm) wavelength areas. However, the absorption of UV light tends to be in the UV-C direction, which is characterized by a maximum absorption peak at a wavelength of 260 nm. The UV absorption of the F0 formula in the UV-C area does not provide significant intensity. This is because UV-C rays are absorbed by ozone in the earth's atmosphere so that the radiation does not reach the earth's surface [34].

Formulas F1, F2, F3, and F+ absorb UV rays at a maximum wavelength of 296 nm, which means they are in the UV-B wavelength region. This can be seen from the maximum absorption peak located at this wavelength. Whether or not there is anti-UV or UV absorption in preparation is reviewed by observing the absorption peak value at a certain wavelength [35]. The presence of UV absorption in formulas F1, F2, and F3 is caused by the active ingredient CQDs and in the F+ formula it is caused by the vitamin C content in it.

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the peel-off mask formulation made from the active ingredient CQDs from rice washing water produces a mask product that has good characteristics, characterized by pH test results, storage stability, dry time, homogeneity, viscosity, spreadability, organoleptic, as well as fluorescence on the product which shows appropriate test results. The UV blocking test produces an SPF value which means that the mask product has UV protection properties with the F3 formula having have the highest SPF value.

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