

Original Article

UV Spectrophotometric Determination and Validation of Hydroquinone in Liposome

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Abstract

The method has been developed and validated for the determination of hydroquinone in liposomal formulation. The samples were dissolved in methanol and evaluated in 293 nm. The validation parameters such as linearity, accuracy, precision, specificity, limit of detection (LOD) and limit of quantitation (LOQ) were determined. The calibration curve was linear in 1-50 µg/mL range of hydroquinone analyte with a regression coefficient of 0.9998. This study showed that the liposomal hydroquinone composed of phospholipid (7.8 %), cholesterol (1.5 %), alpha ketopherol (0.17 %) and hydroquinone (0.5 %) did not absorb wavelength of 293 nm if it diluted 500 times by methanol. The concentration of hydroquinone reached 10 µg/mL after 500 times of dilution. Furthermore, various validation parameters as per ICH Q2B guideline were tested and found accordingly. The recovery percentages of liposomal hydroquinone were found 102 ± 0.8, 99 ± 0.2 and 98 ± 0.4 for 80%, 100% and 120% respectively. The relative standard deviation values of inter and intra-day precisions were <2%. LOD and LOQ were 0.24 and 0.72 µg/mL respectively.

Keywords: Hydroquinone; Liposome; UV spectroscopy; Validation.

Introduction

Hydroquinone (HQ) (1, 4-benzenediol; C₆H₄(OH)₂) is a white crystalline substance. It is highly soluble in water (70 g/L at 25 °C) and the log *n*-octanol/water partition coefficient is 0.59 (Figure 1).

Hyperpigmentation skin disorder is treated with HQ products. This substance inhibits tyrosinase enzyme which is responsible for the first reaction of melanin formation (1). Subsequently melanin decreases and skin becomes depigmented.

Topical drugs have to cross from stratum corneum layer of skin that acts as a barrier against skin permeation (2). For solving this problem, these drugs are formulated with carrier systems

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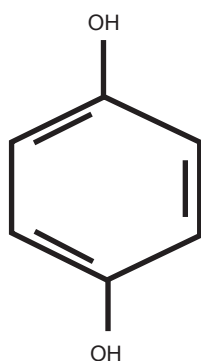


Figure 1. The structure of Hydroquinone.

that are able to increase skin permeation (3). There are reports on different topical liposomes with effective drug or analyte delivery to the skin, such as Amphotricin B (4), Clarithromycin (5), Safranal (6), Octyl Methoxycinnamate (7), alpha tocopherol (8).

So far, the formulations of HQ cream, gel, lotion, and solution are provided and are developed by several techniques to determine HQ. The spectrophotometry, high-performance liquid chromatography (HPLC), thin layer chromatography (TLC), micellarelectrokinetic chromatography (MEKC), and capillary electrochromatography (CEC) techniques (9-19) determine HQ in various matrices such as air, waste photographic solutions, cream, and lotion. Fortunately, HQ could be determined by spectrophotometry technique that is fast, available and simple.

The objective of this study was to determine HQ in liposomal samples by spectrophotometry and to obtain validation parameters.

Experimental

Material and methods

Phospholipid S 100 (Phosphatidylcholine (PC) from soybean Lecithin) was obtained from Lipoid Company. HQ, cholesterol, sodium metabisulfite and chloroform (analytical grade) were purchased from Merck. Alpha ketopherol acetate and methanol (analytical grade) were purchased from Applichem and Chemical Pars respectively.

Instrumentation

Buchi rotary evaporator (R-210), IKA

T10 homogenizer, Cecil 9500 Double Beam Spectrophotometer and Shimadzu balance with 0.1 mg accuracy were used through the experiments.

Preparation of HQ liposomes

Liposome dispersion samples were prepared by a chloroform film method [20] with homogenization. Liposome formulations composed of S100(7.78 %), cholesterol (1.5 %), alpha ketopherol (0.17 %) and HQ (0.5 %) w/v were dissolved in 15 mL chloroform and 5 mL methanol. Thin film layer was formed by vacuum-desiccated the solution by Buchi rotary evaporator (R-210), then was flushed with nitrogen gas for 1 min. The thin film was re-suspended in solution of 0.01M phosphate buffer (pH 6) with sodium metabisulfite (0.1%) slowly, and swelled by shaking hand, vortex and final liposome solution homogenized for 5 min by 2000 rpm speed of IKA T10 homogenizer.

Preparation of HQ-free of liposome (placebo)

The preparation of HQ-free of liposome was the same preparation of HQ liposome, but HQ was not added to primary solution.

Preparation of HQ standard solutions

For construction of the calibration curve, accurately weighed HQ (500 mg) was transferred to a 100 mL volumetric flask and dissolved in distilled water. 2 mL from this solution transferred to 100 mL volumetric flask and complete the volume with methanol, stock solution was obtained. Stock solution diluted by methanol to obtain 1, 8, 10, 12, 20, 30, 40, 50 µg/mL concentrations (triplicate). The standard solutions were prepared daily.

For the precision studying, hydroquinone 5 mg/mL solution in water was prepared then it was diluted 500 times by methanol to obtain a final concentration of 10 µg/mL (triplicate).

UV method

Accurate volume of HQ liposome (equivalent to 5 mg of HQ) was transferred to a 50 mL volumetric flask and dissolved in methanol to obtain a concentration of 100 µg/mL. An aliquot of this solution was diluted in methanol to obtain a solution with final concentration of 10 µg/mL.

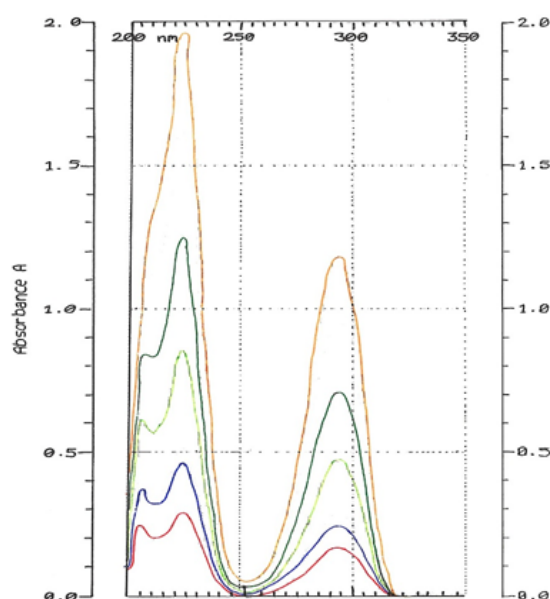


Figure 2. Overlay of hydroquinone standard solutions in different concentrations.

Method validation

For validation studying, the International Conference on Harmonization (21) and AOAC International Guidelines (22) for Validation of Analytical methods were used.

Linearity

The calibration curve was obtained at eight concentration levels of HQ solutions (1-50 $\mu\text{g/mL}$). By the least square regression method the linearity was evaluated with triplicate determinations at each concentration level.

Precision

The degree of aggregate among test results was controlled when a method was applied repeatedly. Variation in intra-day and between days (inter-day) was analyzed. The intra-day and inter-day precision was determined by analyzing same concentration of HQ (10 $\mu\text{g/mL}$).

Accuracy

An accurate volume of HQ liposome (equivalent to 5 mg of HQ) was transferred to a 50 mL volumetric flask and dissolved in methanol (100 $\mu\text{g/mL}$). Aliquots of this solution and 3, 5 and 7 mL of a HQ stock solution (100 $\mu\text{g/mL}$) were transferred into 100 mL volumetric flasks and then methanol was added to make up

the volume to give final concentrations of 8, 10 and 12 $\mu\text{g/mL}$. All solutions were prepared in triplicate and analyzed.

Specificity

The specificity was evaluated by analyzing HQ-free of liposome, where in the sample matrix was analyzed without the analyte. The system result was examined for the presence of interferences or overlaps with the HQ result. HQ-free of liposome solution (placebo) were diluted 10, 100 and 500 times by methanol and their spectrums was obtained.

Limit of detection (LOD) and limit of quantitation (LOQ)

The limit of detection (LOD) of HQ was evaluated from the slope (S) of calibration curve and the standard deviation of the blank (δ) using equation as (23)

$$\text{LOD} = 3.3 \delta / S$$

The minimum quantity of drug that can be quantified by the instrument is defined LOQ. The LOQ were evaluated from the slope(S) of calibration curve and the standard deviation of the blank (δ) using equation as:

$$\text{LOQ} = 10 \delta / S$$

Results and Discussion

The UV is a rapid and easy method for determination of HQ in liposome. The range of calibration curve was constructed in 1-50 $\mu\text{g/mL}$ in 293 nm. The method was validated according to ICH Q2B Guidelines for validation of analytical procedures in order to determine the linearity, LOD, LOQ, precision and accuracy for the HQ.

Linearity and range

The spectrums of HQ standard solutions were obtained (Figure 2) and the linearity was determined by plotting standard calibration curve for the concentration range 1-50 $\mu\text{g/mL}$ as shown in Figure 3.

The Correlation Coefficient was $r^2 = 0.9998$ that showed excellent linearity.

Specificity

HQ-free Liposome Spectrum in different

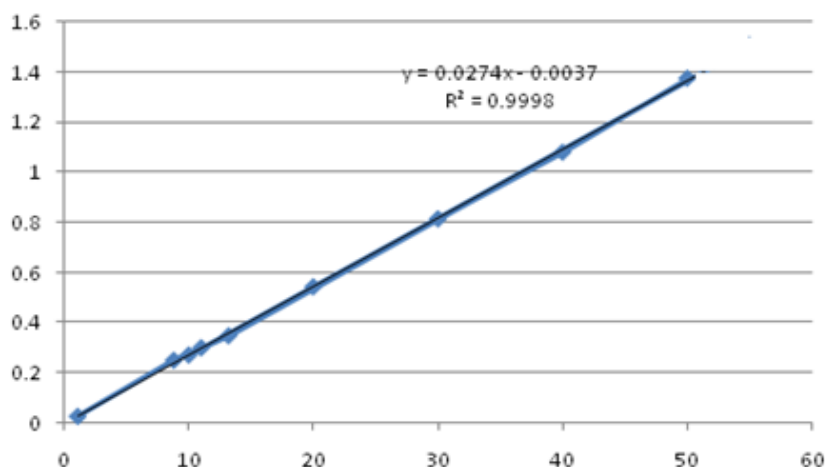


Figure 3. Calibration curve of hydroquinone standard solutions in 1, 8, 10, 12, 20, 30, 40, 50 µg/mL concentrations.

dilutions was outlined in Figure 4. When it was diluted 500 times, there was no absorption in 293 nm. The 2-spectrum overlay of HQ-free liposome solution with 500 times of dilution and HQ standard solution (10 µg/mL) didn't show any interface in 293 nm (Figure 5). Also, absorption solution of HQ standard (10 µg/mL) mixed with HQ-free liposome solution diluted 500 times was the same HQ standard solution (Figure 6).

Accuracy

The recovery (%) for HQ was 102 ± 0.8 , 99 ± 0.2 and 98 ± 0.4 for 80%, 100% and 120% respectively. The method is accurate for quantitative estimation of HQ in liposome clearly.

Precision

Variation in intra-day and between days (inter-day) was analyzed. By analyzing same

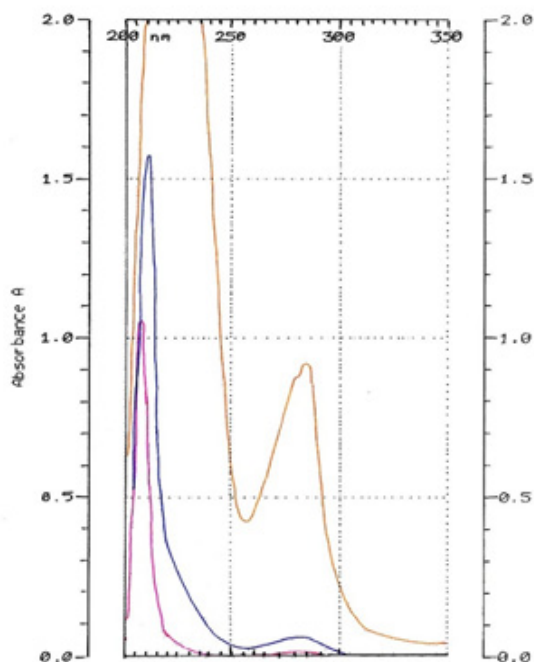


Figure 4. Hydroquinone-free Liposome Spectra in 10 (orange), 100 (blue) and 500 (pink) time dilutions.

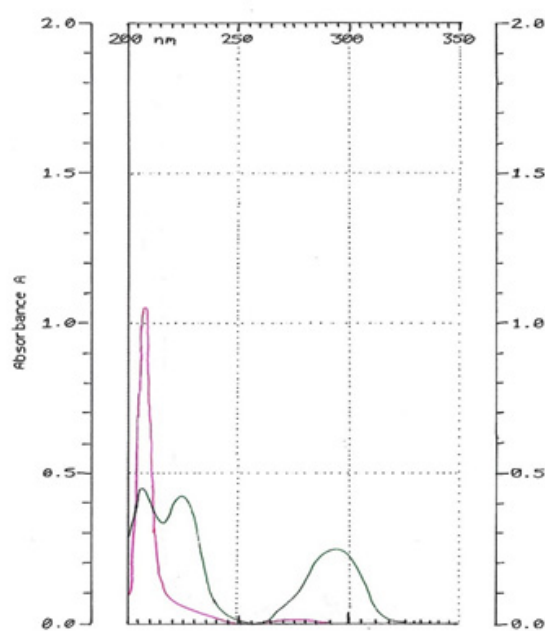


Figure 5. Hydroquinone-free liposome solution diluted 500 times (pink). HQ standard solution in 10 µg/mL concentration (green).

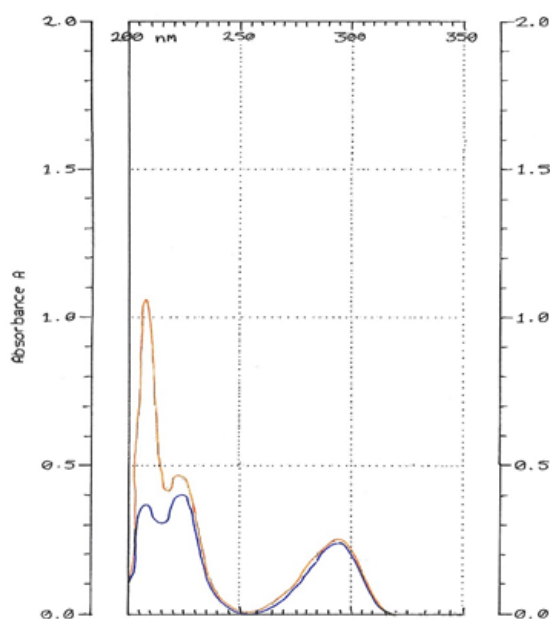


Figure 6. Hydroquinone standard solution (10 µg/mL) mixed with Hydroquinone-free liposome solution diluted 500 times (orange). Hydroquinone standard solution in 10 µg/mL concentration (blue)

concentration of HQ (10 µg/mL), the intra-day and inter-day precision was determined. The study showed precision of inter-day and intra-day as 0.9 and 1.5 % respectively. The RSD (%) value of <2% suggests that the precision is acceptable.

LOD and LOQ

LOD and LOQ were found to be 0.24 and 0.72 µg/mL respectively.

Conclusion

It was concluded from the above results and data that spectrum of liposome in methanol didn't interfere with HQ in 293 nm if liposome solution was diluted 500 times. The concentration of HQ in liposomal HQ solution was 5 mg/mL; therefore, after being diluted (500 times) by methanol, the HQ concentration reached to 10 µg/mL. This dilution was the best dilution for sample preparation in the study of HQ with liposomal matrix by UV spectrophotometry. The molar ratio of HQ and the substances contributed in liposome was an important factor in dilution rate and in removing liposome absorption. The results of validation parameters showed that this

method is acceptable for HQ determination in liposome.

References

- (1) Palumbo A, d'Ischia M, Misuraca G and Prota G. Mechanism of inhibition of melanogenesis by hydroquinone. *Biochim. Biophys. Acta.* (1991) 1073: 85-90.
- (2) Barry BW. Mode of action of penetration enhancers in human skin. *J. Control Release* (1987) 6: 85-97.
- (3) Samad A, Sultana Y and Aqil M. Liposomal drug delivery systems: *Curr. Drug Deliv.* (2007) 4: 297-305.
- (4) Layegh P, Rajabi O, Jafari MR, Emamgholi Tabar Malekshah P, Moghiman T, Ashraf H and Salari R. Efficacy of topical liposomal amphotericin B versus intralesional meglumine antimoniate (Glucantime) in the treatment of Cutaneous Leishmaniasis. *J. Parasitol. Res.* (2011) 2011; 5.
- (5) Sazgarnia A, Zabolinejad N, Layegh P, Rajabi O, Berenji F, Javidi Z and Salari R. Antileishmanial activity of liposomal clarithromycin against *Leishmania major* promastigotes. *Iran. J. Basic Med. Sci.* (2012) 15: 1210-1214.
- (6) Golmohammadzadeh S, Imani F, Hosseinzadeh H and Jaafari MR. Preparation, characterization and evaluation of sun protective and moisturizing effects of nanoliposomes containing safranal. *Iran. J. Basic Med. Sci.* (2011) 14: 521-533
- (7) Golmohammadzadeh S, Jaafari MR, kadimi N and Greenoak G. Determination of SPF and moisturizing effects of liposomal and conventional formulations of octyl methoxycinnamate as a sunscreen. *Iran. J. Basic Med. Sci.* (2007) 10: 110-199.
- (8) Tabandeh H and Mortazavi AR. An investigation into some effective factors on encapsulation efficiency of alpha-tocopherol in MLVS and the release profile from the corresponding liposomal gel. *Iran. J. Pharm. Res.* (2013) 12: 21-30.
- (9) Nanni EJ, Lovette ME, Hicks RD, Fowler KW and Borgerding MF. Separation and quantitation of phenolic compounds in mainstream cigarette smoke by capillary gas chromatography with mass spectrometry in the selected-ion mode. *J. Chromatogr.* (1990) 505: 365-374.
- (10) Firth J and Rix I. Determination of hydroquinone in skin-toning creams using high-performance liquid chromatography. *Analyst.* (1986) 111: 129-132.
- (11) Chao GK-J and Suatoni JC. Determination of phenolic compounds by HPLC. *J. Chromatogr. Sci.* (1982) 20: 436-440.
- (12) Borremans M, Beer J and Goeyens L. Experimental and statistical validation of HPLC analysis of hydroquinone and its 4-methoxyphenol, 4-ethoxyphenol and 4-benzyloxyphenol ethers in cosmetic products. *Chromatographia.* (1999) 50: 346-352.
- (13) Penner NA and Nesterenko PN. Simultaneous determination of dihydroxybenzenes, aminophenols

- and phenylenediamines in hair dyes by high-performance liquid chromatography on hypercross-linked polystyrene. *Analyst*. (2000) 125: 1249-1254.
- (14) Sirajuddin, Bhanger MI, Niaz A, Shah A and Rauf A. Ultra-trace level determination of hydroquinone in waste photographic solutions by UV-vis spectrophotometry. *Talanta*. (2007) 72: 546-553.
- (15) Desiderio C, Ossicini L and Fanali S. Analysis of hydroquinone and some of its ethers by using capillary electrochromatography. *J. Chromatogr. A* (2000) 887: 489-496.
- (16) Uddin S, Rauf A, Kazi TG, Afridi HI and Lutfullah G. Highly sensitive spectrometric method for determination of hydroquinone in skin lightening creams: application in cosmetics. *Int. J. Cosmetic. Sci.* (2011) 33: 132-137
- (17) López García P, Rocha Miritello Santoro MI, Kedor-Hackmann ER and Kumar Singh A. Development and validation of a HPLC and a UV derivative spectrophotometric methods for determination of hydroquinone in gel and cream preparations. *J. Pharm. Biomed. Anal.* (2005) 39: 764-768.
- (18) Cun-Guang Y. Progress of optical determination for phenolic compounds in sewage. *J. Environ. Sci.* (1998) 10: 76-86.
- (19) United States Pharmacopeia and National Formulary (USP 29-NF 24); United Book Press, Maryland (2006) 1083.
- (20) Szoka F and Papahadjopoulos D. Comparative properties and methods of preparation of lipid vesicles (liposomes). *Annu. Rev. Biophys. Bioeng.* (1980) 9: 467-508.
- (21) ICH, Q2 (B) validation of analytical procedure, text and methodology, international conference on Harmonization (1995).
- (22) AOAC. Official methods of analysis of the Association of Official Analytical Chemists. Association of Official Analytical Chemists, Washington DC (1990) 15.
- (23) Amanlou M, Ghazi Moghadam A, Barazandeh Tehrani M and Sourri M. Validated spectrophotometric method for determination of tamsulosin in bulk and pharmaceutical dosage forms. *Iran. J. Pharm. Res.* (2014) 13: 81-86.

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