WORLD JOURNAL OF PHARMACY AND PHARMACEUTICAL SCIENCES
ISSN 2278 – 4357 Impact Factor 8.025
Volume 14, Issue 12, 672-691 Review Article Coden USA: WJPPAJ

REVIEW ON PHOTOSTABILITY STUDIES AND METHODS TO ENHANCE PHOTOSTABILITY

Manasi Kulkarni*, Nida N. Mulla, Sanjay K. Bais

India.

Article Received on 02 Nov. 2025,
Article Revised on 24 Nov. 2025,
Article Published on 01 Dec. 2025,

https://doi.org/10.5281/zenodo.17745008

***Corresponding Author**
Manasi Kulkarni
India.

How to cite this Article: Manasi Kulkarni*, Nida N. Mulla, Sanjay K. Bais. (2025). Review On Photostability Studies and Methods To Enhance Photostability. World Journal of Pharmacy and Pharmaceutical Sciences, 14(12), 672–691.

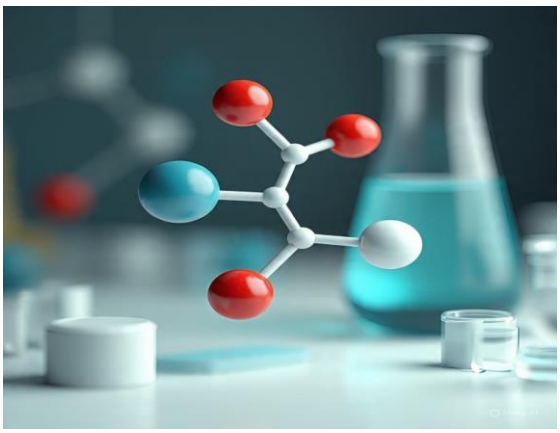

Fig. No. 1

ABSTRACT

In the Quality of medication in which, Photostability of medications and drugs products is a mandatory step in the product development process. The purpose of these investigations is to guarantee the formulated products' safety, effectiveness, and quality during production, storage, and usage. The notion of photostability, associated elements, and the body of literature in the topic are all covered in this review. It discusses the kinetics of photochemical reactions, defines photophysical processes, outlines the functional groups crucial to drug photoreactivity, and emphasizes the relevance of photochemistry in photostability investigations. The ICH guideline's standards and the photostability assessment of medications are enlisted. There are guidelines given on the labelling of formulations. Also covered are the several techniques for photostabilizing liquid and solid dosage forms. The problem of photostability in drugs is examined and ways to increase photostability in formulation. This review addresses formulation properties that affect photostability, variables affecting photostability, and the mechanism of photo-degradation with examples.

➢ **KEYWORDS**: Photostability, Photoreactions, Degradation, Packaging, Effectiveness.

1] INTRODUCTION

In the Industrial business, assessing the photochemical stability. There are wide rage of drugs which are sensitive towards light hence, they can degrade during manufacturing, warehoushing and Taking it. This can results in decrease in potency and effectiveness and adverse reactions of the drugs. Both artificial light (such as fluorescent light) and sunshine (ultraviolet light) can have an impact on medications that are sensitive to light. The oxidative breakdown of medications and their eventual toxicity to human tissue may be exacerbated by sunlight's ability to interact with endogenous substrates and change the agent into harmful substance and create reactive oxygen species. on the rate of a photochemical process. A product's active ingredients' method of stabilization may be revealed by examining the photochemical reactions. Free radical species that produce photoproducts are involved in these reactions, which are frequently intricate Understanding how pharmaceuticals behave photochemically can help with product handling, labeling, and packaging. Products can be shielded from the damaging effects of light by using the right containers and packing materials. A drug's sensitivity to a specific light spectrum might change depending on its chemical makeup, photoreactivity, and dosage form type. The strength and wavelengths of the radiation source as well as the container's transmission properties may have an impact of medications and medicinal products is a crucial step in the formulation development process. There have been several publications on photostability associated topics on the medications, including monographs details and reviews. The pharmacopoeias and other publications also contain the data on stability and storehouse of medications.[1,2,3]

➢ Objectives of Photostability studies

The Photostability Studies' Goals Given that medications and adjuvants can be both photosensitive and photoinstable, understanding the photostability of these compounds and their formed products is essential for assessing the following:

(i) The basic properties of photostability.

(ii) The chemical and physical changes brought on by light exposure

(iii) The mechanisms and pathways of photodegradation.

(iv) The products' shelf life.

(v) Agents used to determine effectiveness in photostability.

(vi) Requirement that the formulation parameters be changed.

(vii) The necessity of taking steps to decrease the effect of light exposure during the production, labeling, packaging, shipping, and storage processes.

(viii) The biological effects of light.

(ix) The designing of the packaging like primary and secondary.[4]

Photostability: Photostability is the term used to describe how a medication or drug product reacts to exposure to visible, UV, and solar light while it is solid, semisolid, or liquid and undergoes a physical or chemical change. The drug's response to light absorption and excitation can be explained by either photosensitization events involving intermolecular energy transfer or photodegradation (photolysis) reactions involving the production of free radicals. Primary (photochemical) and secondary (chemical) reactions produce the final products of these processes.[5,6]

The various ranges of the wavelength is given in the following which gives idea of the Electromagnatic spectrum of the agents. The UVA, UVB, or visible light are involved in most of the reactions.

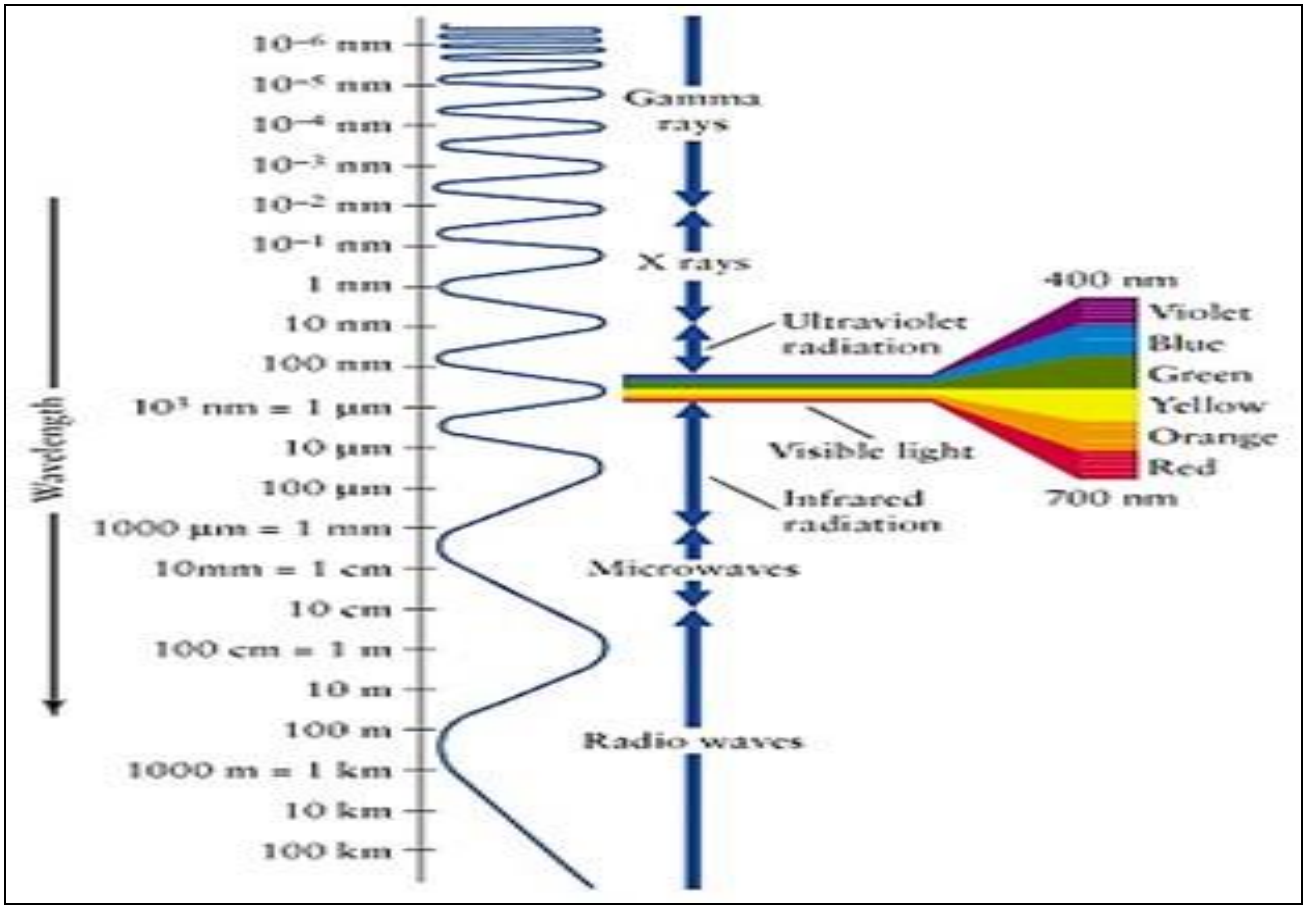

Fig. No 2: Electromagnatic Spectrum.

➢ **Conditions for the Photostability Research Take into account**

(i) Drug's solvability and reaction medium selection.

(ii) The drug molecule's spectral properties.

(iii) The medication molecule's susceptibility to visible, UV, and solar rays.

(iv) Radiation source and utensils should be suitable for the drug molecule's spectrum properties.

(v) Understanding of the photodegradation process and the characteristics of the products derived by initial research.[5,6]

➢ **The Biological Effects of Light on Drugs Products**

The biological effects of light on medications that are photodegrading are significant. biological reaction includes several adverse reactions processes photosensitization, phototoxicity, and photoallergy, among others. Sunlight's UV rays is typically divided into three spectral ranges: UVA (320–400 nm), UVB (290–320 nm), and UVC (270–290 nm). Because ozone absorbs UVC rays, they are not present at sea level. Compared to UVB radiation, UVA radiation has longer wavelengths and is less dangerous. Human skin may be impacted by UVB rays, which can result in pigmentation, erythema, and edema. Additionally, UVB may result in immunosuppression, photoaging, and photocarcinogenesis. When applied as a thin layer to the skin, dermatological preparations or other medications used to treat these conditions may rapidly photodegrade when exposed to light.[7,8,9]

2] Process and Mechanism of Photodegardation

The range characteristics of the drug and the light source's ranges distribution have a significant impact on the photodegradation of pharmacological compounds.[10] The mercury lamp gives well source to the Uv light causes sulpyrine to discolor significantly. In contrast, a fluorescent bulb, which mostly emits visible light, causes less discoloration.[11] The photon is the unit of radiant energy equal to one quantum. The photon's energy is directly impacts on the absorbed radiation's frequency and indirectly to its nanometers. Therefore, a positive charge with a short wavelength (and high frequency) has greater energy. Than in a longer-wavelength positive charge, Therefore, photochemical degradation of pharmaceuticals typically results from the absorption of visible blue, violet, and ultraviolet light (500–300 nm).[12] Understanding the several photophysical processes that Moore[13] has detailed in the absorption of light is essential. As a result of the drug compounds' photodegradation, these may be discussed by further action that produce free radicals and then the end result.

1] Absorption

2] Fluorescence

3] Internal conversion

4] The photoionisation reaction

5] Crossing across systems:

6] Phosphorescence

7] Intersystem conversion

8] Internal conversion

9] represent radical formation

10] Final goods.[13,1]

Time-resolved spectroscopy, laser flash photolysis, and other methods can be used to study all of these events, which typically take place nanoseconds to seconds after the stimulation.[14]

3] Photolytic degradation of Medicine

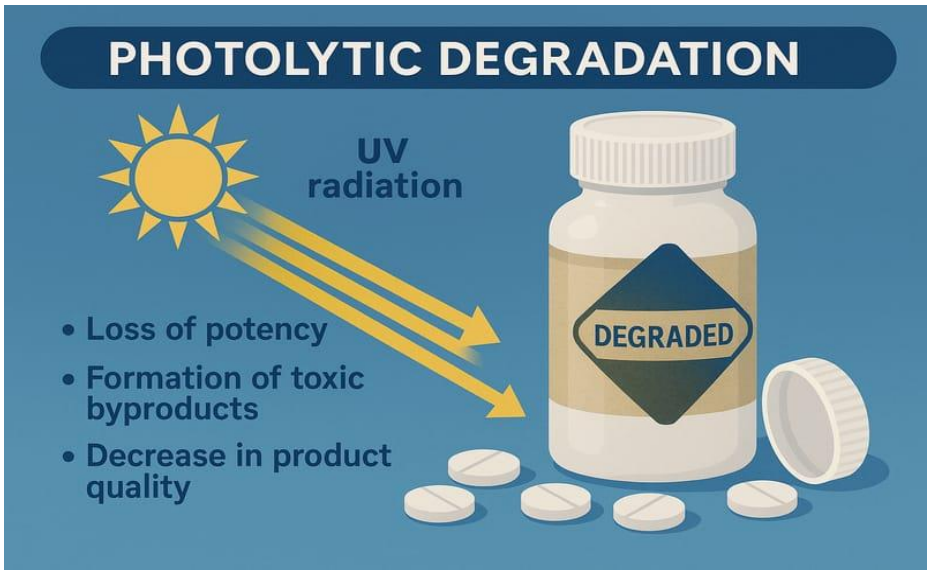

Fig. No. 3: Photolytic degradation of Medicine.

There are several ways that photolytic deterioration might take place, including:

1] Direct Photolysis: When a photon of light is absorbed by a drug molecule, electrical excitation results. Bond cleavage, isomerization, and other chemical processes can occur in the excited molecule.

2] Reactive oxygen species (ROS), including hydroxyl radicals and singlet oxygen, are produced when a photosensitizer molecule absorbs light by indirect photolysis. The medication molecule may react with these ROS, causes it to degrade.[15]

4] Photodegradation reactions

It has been discovered that a wide variety of pharmacological compounds with different chemical structures are photoreactive. When exposed to light, they go through a variety of degradation reactions in organic and aqueous solvents. These reactions can include multiple steps to create the final products, including free radical intermediates. The following are the main ways that medicines photodegrade.[16,17] Numerous instances of drug substance photodegradation reactions involving various mechanisms have been documented. This section provides a few illustrations of the photodegradation reactions.[18,19,20]

1] Reactions of Photoaddition

Riboflavin At pH values greater than 6.0, riboflavin (RF) is photodegraded in the presence of bivalent ions, gives mathematical equation, to generate cyclodehydroriboflavin [CDRF]. In periposition C(9) in the benzene ring, the C–2′ hydroxyl group undergoes intramolecular photoaddition. A RF–mathematical equation complex facilitates the reaction and establishes sterically favorable conditions for the C(9)/O(2′α)-interaction.[21]

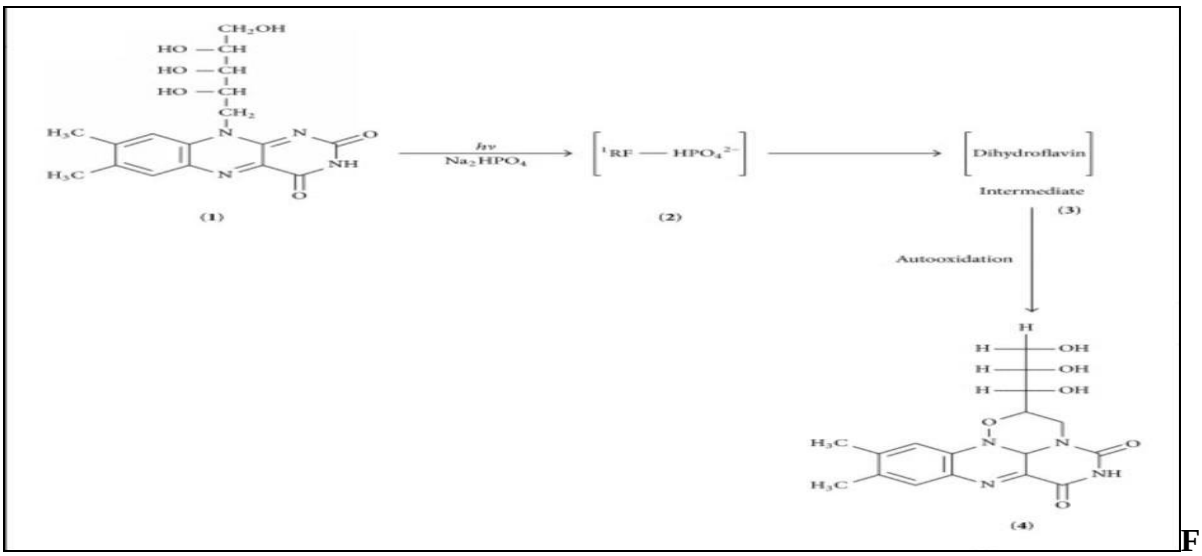

Fig. No. 4: Reactions of Photoaddition.

2] Reactions of Photocyclization: Acid Meclofenamic Around equimolar amounts of 8-chloro-5-methylcarbazole-1-carboxylic acid and 8-chloro-7-methylcarbazole-1-carboxylic acid are formed when water in meclofenamic acid are kept to light.[22]

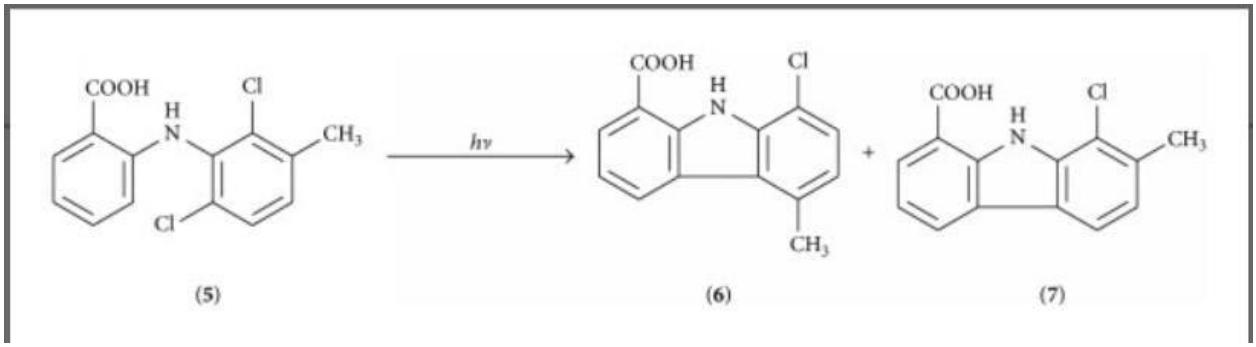

Fig. No 5: Reactions of Photocyclization.

3] **Reaction of Photodealkylation**: Chloroquine When exposed to 240–600 nm light, chloroquine degrades photochemically in distilled water (pH 7.4). MS and NMR spectroscopy have identified the products that result from the main reaction's N-dealkylation . A few of the dealkyl.[23]

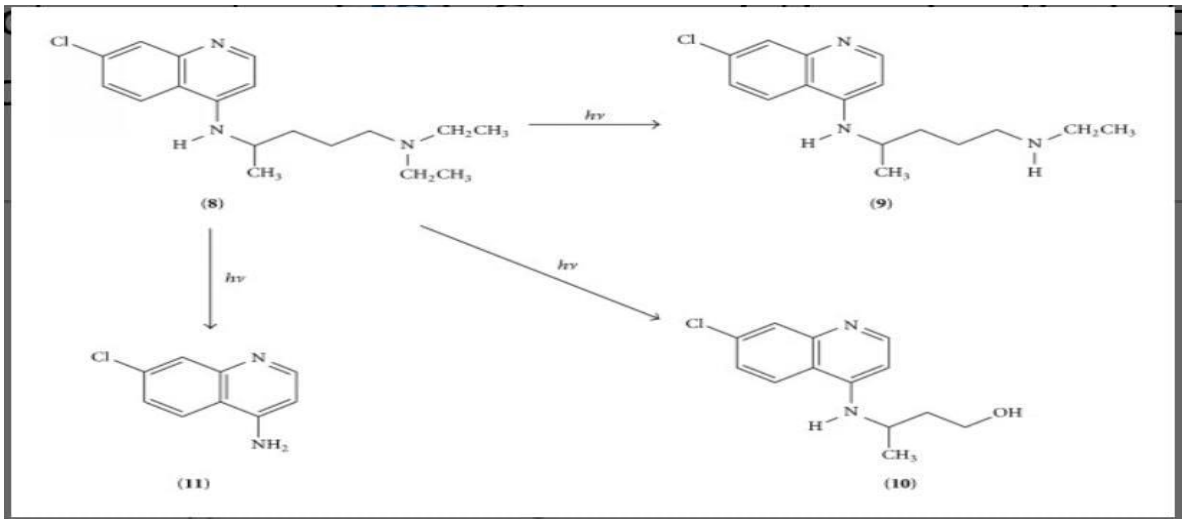

Fig. No 6: Reaction of Photodealkylation.

4] Reactions of Photodehydrogenation: Nifedipine When nifedipine is exposed to visible radiation in 95% ethanol, the molecule dehydrogenates. In aqueous solutions with a pH of 2.0, the degradation occurs most quickly.[23]

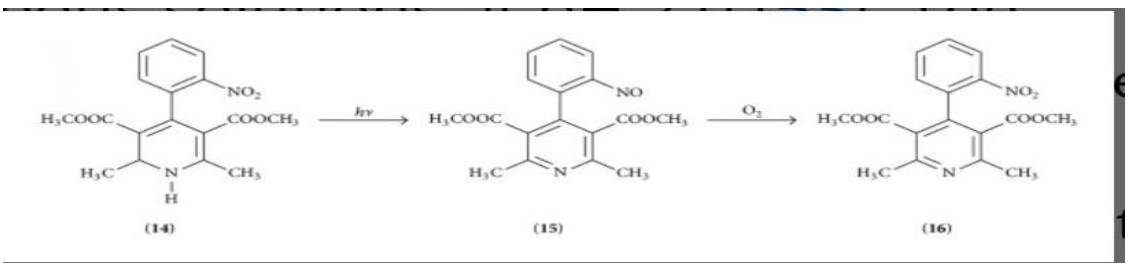

Fig. No 7: Reactions of Photodehydrogenation.

5] Reactions of Photodimerization: Primaquine high-pressure mercury lamp was used to illuminate the water of primaquine diphosphate in order to investigate the photochemical stability of primaquine. GC/MS and NMR spectroscopy have detected the dimer among the many other compounds it yields.[23] In Figure 6, the dimerization reaction is displayed.

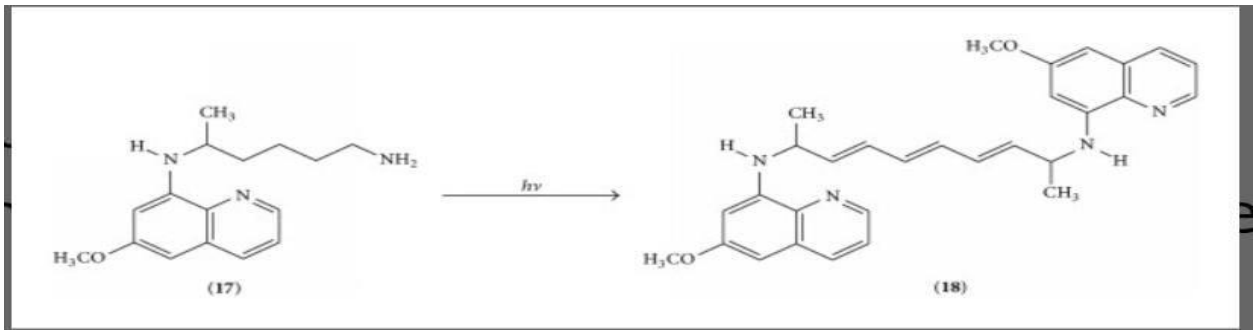

Fig. No. 8: Reactions of Photodimerization.

6] Mefloquine Photoelimination Reactions: Mefloquine is photoeliminated to produce 2,8-bis(trifluoromethyl)-4-hydroxyquinoline in aqueous solutions.[24]

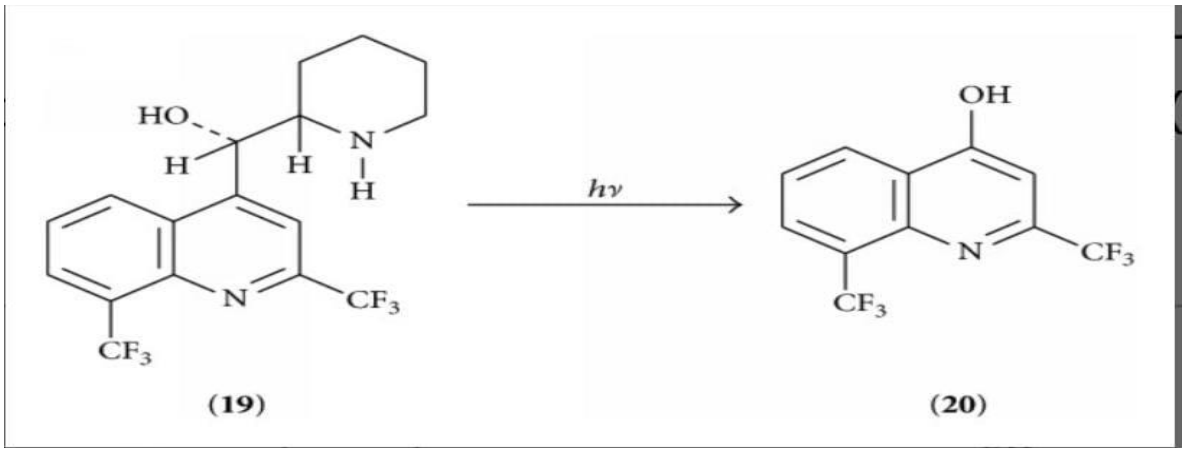

Fig. No 9: Mefloquine Photoelimination Reactions.

7] **Reactions of Photoinduced Hydrolysis**: Sulfacetamide When exposed to UV light in aqueous solutions, sulfacetamide hydrolyzes to sulfanilamide.[25]

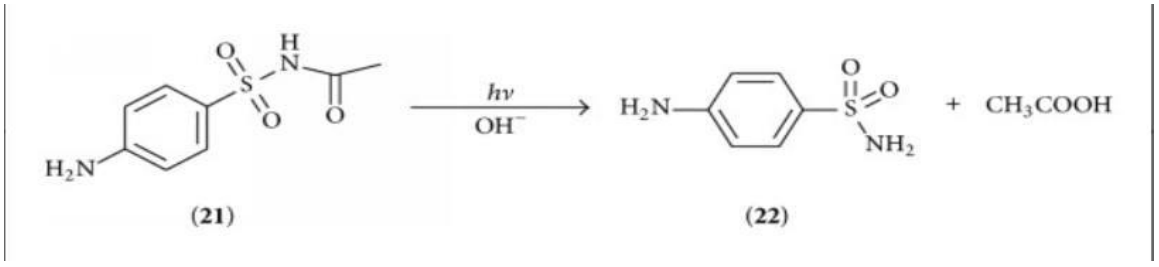

Fig. No 10: Reactions of Photoinduced Hydrolysis.

8] Reactions of Photoisomerization: Aztreonam When kept to UV light, the alkoxyimino group in the side chain of the cephalosporin aztreonam undergoes syn-anti-isomerization in aqueous solutions (pH 5.0)[25]

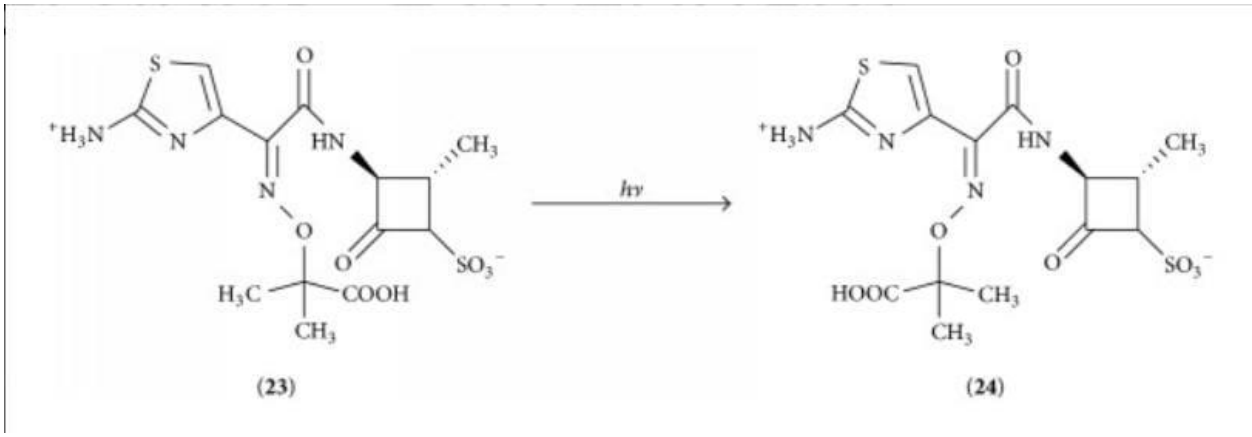

Fig. No 11: Reactions of Photoisomerization.

5] Causes of Photodegradation

The causes of photodegradation on medications are clearly broken down here

1. The most damaging exposure is to light UV radiation (200–400 nm), which breaks chemical bonds. Drugs that are sensitive to light can also degrade when exposed to visible light.

2. Oxygen Is Present Oxidative deterioration results from the free radicals formation and singlet oxygen by light and oxygen.

3. Humidity and Moisture When exposed to light, moisture speeds up oxidation and hydrolysis.

4. Heat from Light Exposure accelerates chemical reactions by raising the ambient temperature.

5. Photo-Sensitizers To enhance breakdown, certain medications, excipients, or contaminants absorb light and transfer energy to the drug molecule.

6. Drug Structural Susceptibility.[25,26]

6] Effects of Photodegradation on Drugs

These are how medications are affected by photodegradation

1. Potency Loss A diminished therapeutic effect results from the breakdown of the active pharmaceutical ingredient (API). For instance, when exposed to light, nifedipine decreases its antihypertensive effects.

2. Toxic Product Formation Byproducts of photodegradation may be poisonous or result in unfavorable reactions. For instance, when exposed to light, tetracyclines produce harmful breakdown products.

3. Physical Appearance Change medication or product discoloration, fading, or precipitation. For instance, when exposed to light, riboflavin (Vitamin B2) solutions turn brown.

4. Decreased Shelf-life & Stability Shorter formulation shelf life due to accelerated degradation.

5. Modified Activity of Pharmacology therapy may be hampered by the distinct or undesirable effects of some deteriorated products.[27,28]

7] Protocols for Photostability Testing

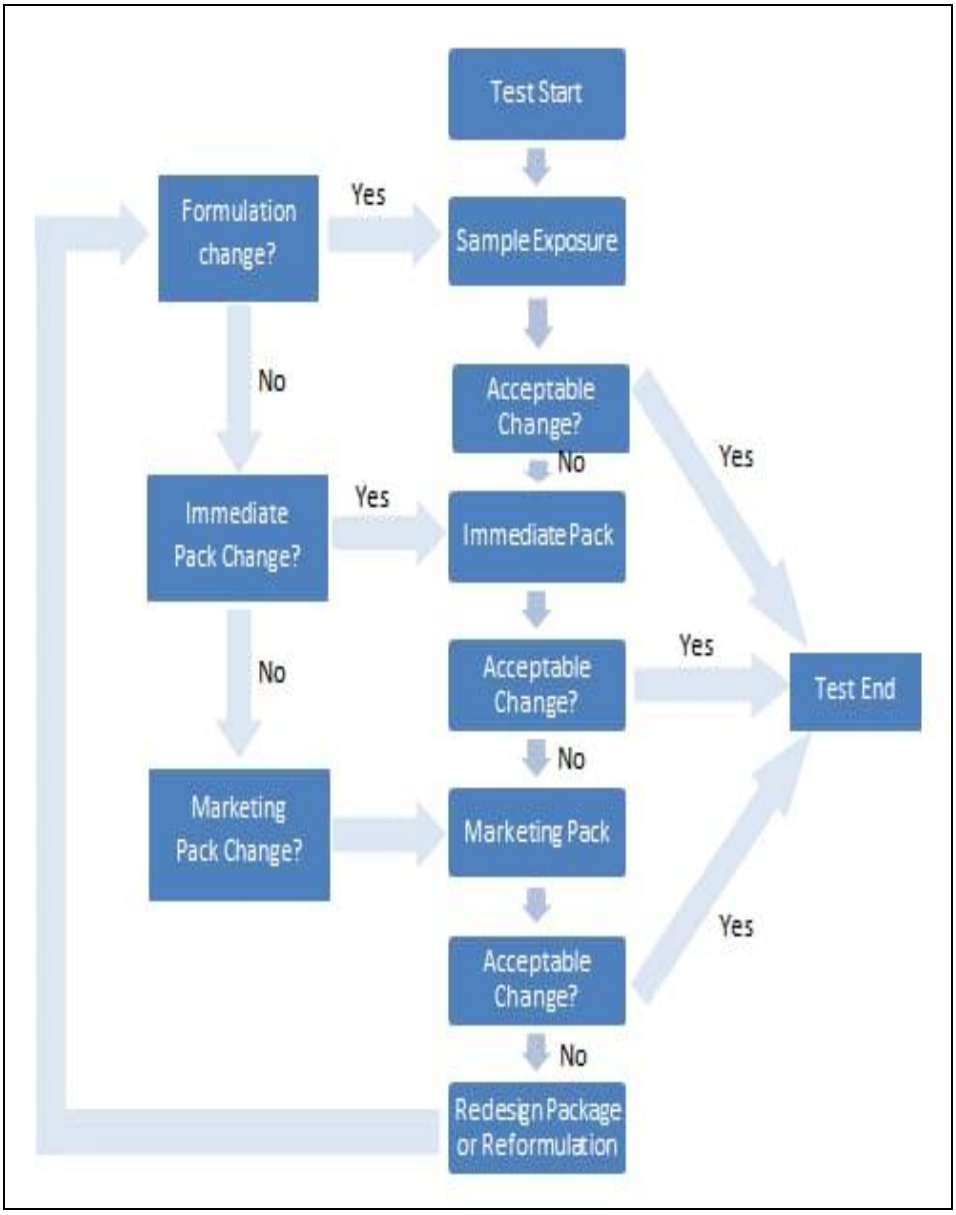

Fig.no 12: Protocols for Photostability Testing.

The Q1B Guideline gave both the suggested tests for drug substances and drug products. These tests included how to prepare samples, how to analyze them, and how to evaluate the results. Confirmatory and forced degradation tests should be included in photostability testing for pharmacological compounds. Studies for pharmaceutical items should be conducted in a step-by-step fashion, beginning with evaluating the completely exposed product and moving on as needed to the product in the immediate pack and subsequently the marketing package.[29, 30]

Tests to determine Stable/Unstable Classification:[31]

- Conditions for Testing of photostability

Table No 01: Conditions for Testing of photostability.

Exposure (k/x days)	Maximum permitted level of Degradation(%)
Liquids	
8	0.5-1
<180	0.1-0.5
85-180	0.5-1
Solids	
<360	0.5-1
360-1080	0.5-1
180-160	0.5-1

8] Factors Influencing Photostability of Drugs

The factors affecting the photostability of drug substances are as follows:

1] Excipients and formulation: Stability testing is usually required since it can be challenging to predict the effects of excipients and commonly used stabilizers, as well as photostability. An essential component of the study and creation of novel drug compounds and products should be the assessment of drug-light interactions. The photodecomposition of the active compounds is probably influenced by the formulation type and the excipient.[32]

Excipients have the ability to start, spread, or take part in photochemical reactions. Solution kinetics will be used to choose the buffer and pH for liquid formulations. The photodegradation processes of riboflavin in aqueous solution may potentially be impacted by buffer.[33] Although the medication molecule itself is not light-absorbing at wavelengths greater than 300 nm, metalion contamination and compatibility with packing materials (plastic plugs) are significant considerations for parenterals.[34]

2] Solid dosage forms: Not much research has been done on the photostability of medicinal compounds in solid preparations. This is mostly because, in contrast to solutions, the degree

of drug breakdown in solid states is lower. But since 2002, photostability testing has been required as a crucial component of stress testing according to ICH recommendations (ICH Q1B, 2002). Since then, new medications have been added to the list of medications that are sensitive to light. The photochemical process occurs on the product's surface in the solid state (such as tablets, capsules, or powder), leaving the interior intact. Numerous factors influence the rate of deterioration in the solid dosage form's surface layer.[35,36]

3]Particle size: Because the increasing surface area kept to light, the rate of degradation increases as the particle size decreases. However, when combined into tablets, the medication powder's particle size will not have any impact.[37]

4]Drug content: Higher drug concentrations slow down the rate at which medications break down in solution. This phenomenon is caused by the drug ingredient itself absorbing light, which shields the molecules in the inside space of the action chamber. However, for solid dosage , photostability rises as drug concentration increases.[37]

5] Tablet geometry: The drug content determines the tablet's size and diameter. The drug's photostability was enhanced by increasing the diameter. Despite the small difference, it matters. Tablets with a biconvex shape showed greater degradation than tablets with a biplanar shape. But there wasn't much of a difference.[38]

6] Method of preparation: Granulation or direct compression are two methods for making tablets. Granulation will make tablets less photostable.[39]

7] SolutionsConcentration: Higher drug concentrations slow down the rate at which pharmaceuticals break down in solution. This behavior is caused by the drug material itself absorbing light, which shields the molecules in the inside region. If a solution contains a high concentration of the pharmacological component, the majority of the light will be absorbed at the surface of the sample. As result, a concentrated solution is probably.

8] PH and Ionization: The photodegradation process will be greatly impacted by pH. Certain medications degrade at lower pH values, whereas others do so at higher pH values. At pH 4.0 and 7.4, diltiazem degrades slowly; at pH 9.0, however, there is a significant degradation. Photochemistry should therefore be pH dependant. The stability may be impacted by substances that alter pH. By promoting the positive ions in active state of reacting species, the

phosphate buffer is known to affect the photochemical characteristics of chemicals (such as tyrosine).

9]Ionic strength: According to a study, increasing the ionic strength can photostabilize some medications by forming a protective layer of solvated ions surrounding the reactive molecule. As more medication was in ionic form, the photodegradation speed of reaction increased along with solution's different charges.[40]

10]Oxidation: Since oxygen is essential to many photochemical reactions, lowering the oxygen content would stabilize the end product. Antioxidants and chelating agents have unpredictable effects. The effect needs to be carefully assessed because it is very dependent on the surroundings and lighting. Additionally, it is well known that super oxide rapidly reduces Fe(III)-EDTA chelates; as a result, EDTA will not prevent photodegradation in these situations.[41,42,43]

9] Photostabilization Methods to Enhance in Drug Formulation

A pharmacological molecule's photostabilization in product can be mostly categorized follows:

(a) photostability attained by standard techniques

(b) A unique medication delivery mechanism was used to achieve photostability.

1] Conventional Approach: Traditional methods: Photolytic processes can be readily avoided by blocking light. This can be accomplished by putting the medication in a packaging that has protective, opaque, or amber-colored containers that is, containers that block out light of the wavelengths that drive the action. The limits of light transmission in glass and plastic containers are specified by a number of pharmacopoeias. When using amber glass as the sole method of photo protection, its stabilizing impact is unsatisfactory, so to prevent such types of degradations Quenchers or scavengers can be used also Antioxidants like Ascorbic acid, beta keratin could be used to improve physical stability.[44]

2] Formulation approach: Changing the photoreactivity through complexation with appropriate carriers is an alternative strategy. For several medications, inclusion complexation with cyclodextrins (CDs) has decreased the degree of photodegradation. CDs are cyclic oligosaccharides that can combine with a wide range of agents to produce non-covalent inclusion complexes. The way that CDs interact with labile chemicals can either

speed up or slow down drug degradation, or it can have no effect at all on the reactivity of molecules. Labile drug molecules are encapsulated at the molecular level by CD complexation, which provides molecular shielding, protecting them from a variety of degradation processes.The physico-chemical properties would vary if the salt's shape were altered. Pharmaceutical photostability was also found to be enhanced by complex formation with organic acids and salts2. Amlodipine's new crystalline adipicsalt form has better photostability.[45,46]

- **Inshort**

Numerous tactics are used to counteract photodegradation; these can be divided into two categories:

• Traditional and formulation techniques. Light-absorbing pigments, antioxidants, and light-resistant containers are examples of conventional techniques. Light-resistant coatings, inclusion complexation (e.g., with cyclodextrins), and formulations such as liposomes, microspheres, microcapsules, and ion-exchange resins are examples of formulation techniques which can work as shield for the active drug. The commercial manufacturing of photostable formulations has been made possible by recent research that demonstrate the efficacy of cyclodextrin complexation and ion-exchange resins.[47]

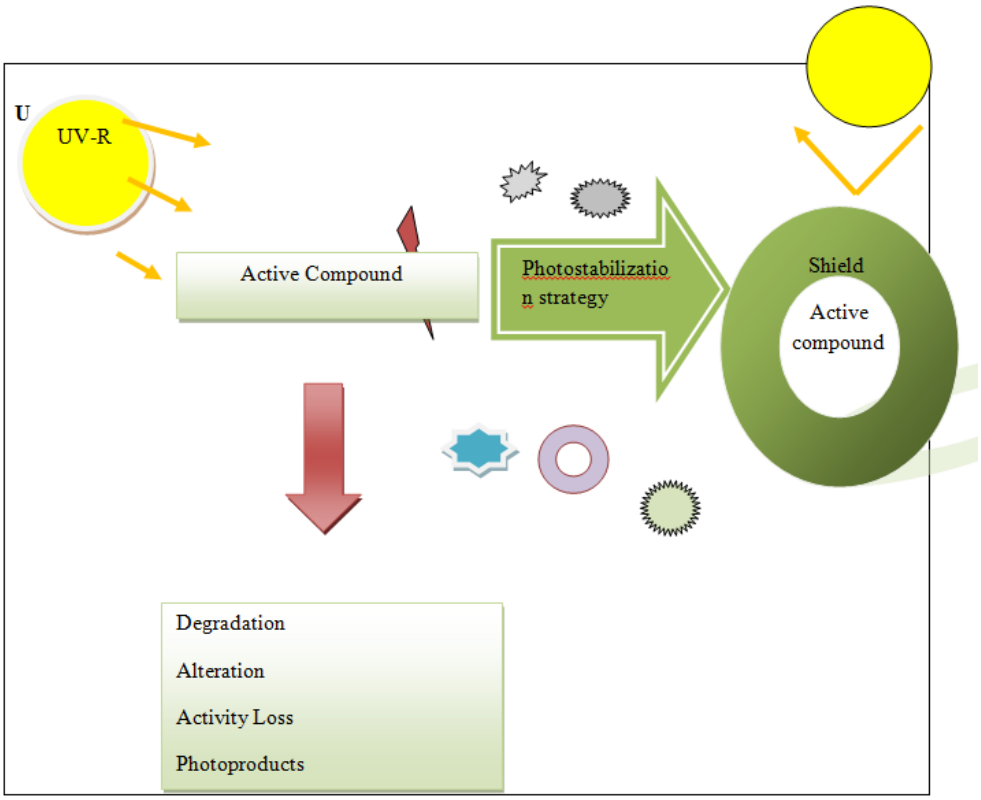

Fig. No 13: Mechanism of Photodegradation.

10] Packaging and Storage requirements for Photosensitive formulation

Because the medication ingredients are light-sensitive, an efficient packaging system is necessary to shield them from photochemical deterioration. For light-sensitive medications and manufactured goods, the pharmacopoeias specify requirements for storage (such as protection from light) and containers (such as light-resistant). The specifications for pharmaceutical packaging systems vary depending on whether the product is a liquid or solid dose form. Compared to a solid dosage form, a liquid dosage form has a higher likelihood of interacting with the container. Through photostability tests, the effectiveness of a packaging method for a certain drug or product can be assessed. A product can be protected fromlight by using an opaque or amber-colored container.[48,49]

1] Because **amber glass** transmits light above roughly 470 nm, it is appropriate for medications that absorb in the UV area.

This can likewise be done using an opaque secondary package. The light transmission properties of containers intended for use with photosensitive medications can be assessed using light transmission testing.[50] The effects of photostability on the production, packing, and storage of prepared products have been examined by Templeton et al, who stress the necessity of taking the right precautions to safeguard photosensitive items during these procedures.[51]

2] Containers that are completely opaque: Some containers are completely opaque, blocking all light with additions like carbon black.

3] Alu-Alu blister packs: These packs create a total light and moisture barrier by using cold-formed aluminum foil for the lid and base.

- Packaging that is secondary and tertiary An extra degree of security is offered throughout the supply chain by external packaging;
- Outer cartons: A paperboard carton that also prevents light exposure is usually used to house a product's immediate
- container. The original packing Until the time of use, the medication must be kept in its original, safe container.
- Aluminum foil: After being taken out of their original packaging, medications can be wrapped in aluminum foil for usage in hospitals or pharmacies to offer further light protection. Some pre-filled containers, especially for IVs have a protective overwraps.[52]

- **Packaging Used**

Fig.no 14:Amber coloured bottles.

Fig.no 15: Opaque containers.

Fig. No 16: Alu-Alu packaging (Aluminium blister).

11] CONCLUSION

The most mandatory factor in the production of dosage form research is the evaluation and assesment of the medications intrinsic photostability, which facilitates the creation of stable, secure, and efficient products. Understanding a drug's photostability and how it degrades aids the formulator in evaluating the product and making the required adjustments to extend for its freshness according to suggested storehouse circumstances. Stability of the goods can be then improved by using different photostabilization processes. These investigations aim to guarantee product quality and all required characteristics when it is being used and stored. Understanding how drugs interact with light is essential to creating stable, high-quality dosage forms. Aside from cyclodextrins, there are other well-established drug delivery systems must investigate the ability to provide prevention from photodegradation of the main agent such as ion exchange resins, solid dispersions, and microspheres. It is anticipated that this review offers some insight into this crucial field of drug research and formulation.

12] ACKNOWLEDGEMENT

This Reviwe provides the deep information about the how photosensitive drugs can be handled and stored. The photosensitive drugs and their formulations can be handled with great care and the precaustions to be taken can also be studied. How the Uv , visible or other lights can affects the drugs and their formulation can de determined. The causes and effects shown by the drug formulation after exposed to the light can be seen. The factors affecting drug formulation and its stability can be understood. Due to this the enhancement of photostabilization methods needs to be performed. Hence this types of photosensitive drugs can be packed and stored carefully and the packaging requirements can be fullfiled.Yet the photosensitive agents stability and efficay and potency can be improved and sustained.

13] REFERENCES

1. Her Majesty′s Stationery Office, British Pharmacopoeia, 2013, Her Majestys stationary office, london, Uk.
2. United States Pharmacopeial Convention, United States Pharmacopeia 29, 2012, United States Pharmacopeial Convention, Rockville, Md, USA.
3. J. Ferguson, Photochem. Photobiol., 1995; 62: 954.
4. N. Hayashi, Y. Nakata and A. Yazaki, Antimicrob. Agents Chemother., 2004; 48: 799.
5. Iqbal Ahmed, sofia Ahmed, zubair anwar international Journal of photoenergy/ volume 2016 issue 1/8135608.
6. Iqbal Ahmed, sofia Ahmed, zubair anwar international journal of photoenergy/volume 2016 issue 1/8135608 https://doi.org/10.1155/2016/8/35608.
7. Romanhole R. C., Ataide J. A., Moriel P., and Mazzola P. G., Update on ultraviolet A and B radiation generated by the sun and artificial lamps and their effects on skin, International Journal of Cosmetic Science, 2015; 37(4): 366–370, https://doi.org/10.1111/ics.12219, 2-s2.0-84936891366.
8. Moyal D. and Fourtanier A., D. S. Rigel, R. A. Weiss, H. W. Lim, and J. S. Dover, Acute and chronic effects of UV on skin, Photoaging, 2004, Marcel Dekker, New York, NY, USA, 15–32.
9. Beijersbergen van Henegouwen G. M. J., Medicinal photochemistry: phototoxic and phototherapeutic aspects of drugs, Advances in Drug Research, 1997; 29: 79–170, 2-s2.0-0030816426.
10. M.E. Aulton, pharmaceutics the science Design from Design churchill of Dosage f living stone, edn2, 2002; 131.

11. E.A. Rowlins, Bentley's Textbook of pharmaceutics, Tindall, london, edn., 1995; 8: 148.
12. M.E. Aulton, pharmaceutics the science Design from Design churchill of Dosage f living stone, edn, 2002; 2: 131.
13. Moore DEH.H. Tonneren, Photophysical & photochemic speits of drug stability, Photostability of Drugs & Drugs form 2004; and edition, CRC Prels, Boca Raton, Fla, USA.
14. Navoratum S. H.H. Tonnelen, phochemical & photophysical metho used in the study of chung photorcactivity, The photostability of drugs & Doug formn (2004, 2nd edition. Taylor & Francis, london, UK.
15. Pharma career nov 28 2024 https://www.pharmacareers.in/photolytic-degradation-and-its-prevention/
16. AlbiniA. and Fasani F. and Photostability Chemistry Combridge 1995, Rayal Society of Drugs Photochemistry UK. 23]JT. Picchaki and K. Thoma, Pharmaceutical Photostability and stabilization technology 2007, Informa Healthcare New York, NY.
17. Carstensen J.T., J. T. Carstensen Rhodes, Catalysis, complexation Drug Stability, 2000, 3rd edition, Marcel DeR Dekker, New York, NY, USA, 133-144.
18. Yoshioka s. and Stella V. J., Stability Drugs and Dosage Forms, 2000, hluwer Academic, New York, NY, USA.
19. Ahmad I. and vaid F. H. M., F. A.M. Edwards, Photochemistry aqueous Silva and of flavins in and organic solvents, Flavin Photochemistry and Photobiology, 2006, The Royal Society of Chemistry, Cambridge, UK, 12-40.
20. Schuman Jorns M., Schoellnhammer G. I Hemmerich p., intramolecular addition of the riboflavin Side chain. Anion catalyzed neutral photuchemisty european Journal of 70.1,35-48 Biochemistry, 1975; 57.
21. Philip J. I sealzewski D. H., Photolytic decompon of N-(2,6-dichloro-m-toly anthranilic acid), Journal of pharmaceutical, 1973; 8: nog, 1479-1482.
22. Nord K., Karlsen J., and Tønnesen H. H., Photochemical stability of biologically active compounds. IV. Photochemical degradation of chloroquine, International Journal of Pharmaceutics, 1991; 72(1): 11–18, https://doi.org/10.1016/0378-5173(91)90375-X, 2-s2.0-0025726678.
23. Tønnesen H. H. and Moore D. E., Photochemical stability of biologically active compounds. III. Mefloquine as a photosensitizer, International Journal of Pharmaceutics, 1991; 70(1-2): 95–101, https://doi.org/10.1016/0378-5173(91)90168-n, 2-s2.0-0025797215.Web of Science®

24. Baertschi, S. W., Alsante, K. M., & Tonnesen, H. H. Pharmaceutical Photostability and Photostabilization: A Scientific Perspective.European Journal of Pharmaceutical Sciences, 2016; 88: 63–83.
25. Tonnesen, H. H. (2004).Photostability of Drugs and Drug Formulations. 2nd Edition, CRC Press. Standard reference for degradation mechanisms, effects on potency, toxicity, and stability.
26. https://www.ich.org/fileadmin/Public_Web_Site/ICH_Products/Guidelines/Quality/Q1B/Step4/Q1B_Guideline. pdf.
27. https://www.ich.org/products/guidelines/quality/quality-single/article/stability-testing-photostability-testing-ofnew-drug-substances-and-products.html
28. Abhijjeet Welankiwar et al. Int. Res. J. Pharm. 2013, 4 (9) Creative Commons Attribution-NonCommercialNoDerivatives 4.0 International.
29. K. Kakinoki, K. Yamane, M. Igorashi, M. Yamamoto, R. Teraoka and Y. Matsuda, Chem. Pharm. Bull., 2005; 53: 811.
30. I. Ahmed, Q. Fasihullah and F.H.M. Vaid, J. Photochem. Photobiol., 2005; 78(229): 20.
31. R.A. Reed, P. Harmon, D. Manas, W. Wasylaschuk, C. Galli, R. Biddell, P.A. Bergquist,W. Hunke, A.C.
32. Templeton and D. Ip, PDA J. Pharm. Sci. Technol., 2003; 57: 351.
33. W. Aman and K. Thoma, Int. J. Pharm., 2002; 243(33): 23.
34. A.L. Herbert, L. Lachman and J. Kanig, Pharmaceutical Dosage Forms: Tablets, Marcel dekker.Inc., 2005; 3: 482.
35. H. Tønnesen, Int. J. Pharm., 2001; 225: 1.
36. M. Gandhimathi, M. Manjuladevi, A.S. Ravi, T.K. Majeed and J. Francis, Indian Drugs, 43, 31.
37. V. Andrisano, R. Ballardini, P. Hrelia, N. Cameli, A. Tosti, R. Gotti and V. Cavrini, Eur. J. Pharm. Sci., 2001; 12: 495.
38. M.A. Boyomi, K.A. Abanumay and A.A. Al-Angary, Int. J. Pharm., 243, 107 (2002). 45]. Y. Matsuda, R. Terako and I. Sugimoto, J. Pharm. Pharmacol., 41, 293 (1989) 46]. K. Javidnia, R. Miri, L. Movahed and S. Golrangi, Iran. J. Pharm. Res., 2003; 111.
39. A.C. Kenneth. L.A. Gordon and J.S. Valentino, Chemical Stability of Pharmaceuti-cals, John Wiley & Sons, New York, edn., 1985; 2: 105.
40. H. Tønnesen, J. Karlsen and G.B. van Henegouwen, Z. Lebensm Unters Forsch., 1986; 183: 116.
41. I.N. Demiana and I.B. Lories, HIV & AIDS Rev., 2004; 3: 35.

42. MulchandA. Shende and Rajendra P. Marathe, world journal on pharmaceutical research Doi:10.20959/wjpr201712-9808.
43. L. Coelho, I.F. Almeida, J.M. Sousa Lobo, J.P. Sousa e Silva, International Journal ofPharmaceutics, April 2018; 541(1–225): 19-25 Review.
44. Her Majesty′s Stationery Office, British Pharmacopoeia, 2013, Her Majesty's Stationery Office, London, UK.
45. United States Pharmacopeial Convention, United States Pharmacopeia 29, 2012, United States Pharmacopeial Convention, Rockville, Md, USA.
46. EDQM, European Pharmacopoeia, 2015, 8th edition, European Pharmacopoeial Convention and the European Union, Strasbourg, France.
47. Templeton A. C., Xu H., Placek J., and Reed R. A., Implications of photostability on the manufacturing, packaging, storage and testing of formulated pharmaceutical products, Pharmaceutical Technology, 2005; 3: 68–86. Google Scholar.
48. Her Majesty′s Stationery Office, British Pharmacopoeia, 2013, Her Majesty's Stationery Office, London, UK.
49. Romanhole R. C., Ataide J. A., Moriel P., and Mazzola P. G., Update on ultraviolet A and B radiation generated by the sun and artificial lamps and their effects on skin, International Journal of Cosmetic Science., 2015; 37(4): 366–370, https://doi.org/10.1111/ics.12219, 2-s2.0-84936891366.
50. Moyal D. and Fourtanier A., D. S. Rigel, R. A. Weiss, H. W. Lim, and J. S. Dover, Acute and chronic effects of UV on skin, Photoaging, Marcel Dekker, New York, NY, USA, 2004; 15–32.
51. Beijersbergen van Henegouwen G. M. J., Medicinal photochemistry: phototoxic and phototherapeutic aspects of drugs, Advances in Drug Research, 1997; 29: 79–170, 2-s2.0-0030816426.