



Research Article

# Efficacy of Photosence Mediated Photodynamic Therapy in HeLa Cell Lines

Ahmad Ali<sup>1</sup>, Zaib Ullah<sup>2</sup>, Muhammad Javaid Asad<sup>1\*</sup>, Muhammad Rafi<sup>3</sup>, Muhammad Maqsood<sup>4</sup> and Sajid Mahmood<sup>5,6</sup>

<sup>1</sup>Department of Biochemistry, Arid Agriculture University Rawalpindi, Pakistan

<sup>2</sup>Department of Zoology, Hazara University Sub-Campus Battagram, Khyber Pakhtunkhwa, Pakistan

<sup>3</sup>Department of Zoology/Biology, Arid Agriculture University Rawalpindi, Pakistan

<sup>4</sup>PhotoMedicine BioLab.Pakistan Institute of Engineering and Applied Sciences Nilore, Islamabad, Pakistan

<sup>5</sup>Department of Zoology, Hazara University Mansehra, Khyber Pakhtunkhwa, Pakistan

<sup>6</sup>Department of Zoology, University of Chakwal, Punjab, Pakistan

## Article History

Received: November 11, 2021

Revised: December 05, 2021

Accepted: December 24, 2021

Published: June 28, 2022

## Authors' Contributions

AA designed and conducted the research. ZU reviewed the manuscript. MJA helped in data collection and organization. MR and SM helped in manuscript writing. MM design the tables and graphs.

## Keywords

HeLa cell line, Efficacy, Photosence mediated photodynamic



Copyright 2022 by the authors. Licensee ResearchersLinks Ltd, England, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

**Abstract** | The effect of Photodynamic therapy (PDT) on Hela versatile feasibility underneath outstanding oxygen circumstances becomes quantified by the utilization of the equivalent vintage check. Photodynamic therapy is developing as a potential solution for masses malignancies. The purpose of this task changed into to find the reasonable total of acknowledgment of photosensitizer as medication and portion of laser moderate which may likewise also in addition additionally reason most extreme harmful cell absence of ways of life in vitro and afterward in vivo through the method of way of the utilization of creature models. Photodynamic cure (PDT) is another creating method utilized for greatest malignancies treatment is fundamentally examined. We have planned troublesome and quick orderly tests to have an exam the viability of PDT.

**Novelty Statement** | The study indicates the effect of Photosence Mediated Photodynamic Therapy in HeLa Cell Lines and help in the identification and target sites of the cancer patients. It also the importance in medicines preparation of the specific target cells.

**To cite this article:** Ali, A., Ullah, Z., Asad, M.J., Rafi, M., Maqsood, M., and Mahmood, S., 2022. Efficacy of photosence mediated photodynamic therapy in hela cell lines. *Punjab Univ. J. Zool.*, 37(1): 85-92. <https://dx.doi.org/10.17582/journal.pujz/2022.37.1.85.92>

## Introduction

Because of the increment of poisonous sicknesses like disease, new modalities are standing out enough to be

noticed for their cures. Among those modalities, Photodynamic treatment (PDT) or cure is a recently arising strategy that is widely utilized for delicate tissue sarcoma in the created nations (Hreshchyshyn *et al.*, 1979; Bonnett and Berenbaum, 1989). This field of study hushes up virgins in Pakistan. It is utilized for the greatest disease treatment is fundamentally examined. We have planned

**Corresponding Author: Muhammad Javaid Asad**  
javaidasad@uaar.com.pk

troublesome and quick orderly investigations to have examined the viability of PDT. In light of the addition of harmful afflictions like infection, new modalities are standing apart enough to be seen for their fixes (Kretmer-Birnbaum, 1989; Cadron *et al.*, 2005). Among those modalities, Photodynamic treatment or fix (PDT) is a late-emerging procedure that is generally used for fragile tissue sarcoma in the made countries. This field of study quiets virgin in Pakistan. It is used for most prominent illnesses treatment is in a general sense analyzed. We have arranged an inconvenient and snappy of methodical examinations to have an inspect the reasonability (Stehman *et al.*, 1993).

PDT therapy produces devastation of disease cells and tissues, anyway, 3 significant instruments were proposed. Because of harming of mitochondria, lysosomes and plasma film tumor cells can be executed (Woodburn *et al.*, 1998; Berek *et al.*, 2005; Ullah *et al.*, 2021b). The focus on location might be harmed by utilizing vascular near down number one to apoplexy and balance. Cell resistance device might be changed. By inclination of sensitizer, PDT welcomed on might be broken and its gadget or the medication transport. The span which has come to be unobtrusive within the tissue changed into roughly indistinguishable from in any event one percent of red platelets in distance across, its reach adjusted into around 6-8 $\mu$ m. These qualities for singlet oxygen esteem for the one's arrangements had been significantly more limited (Ma *et al.*, 2001; Zamora-Juárez *et al.*, 2005; Alexiades-Armenakas, 2006; Ullah *et al.*, 2021d). PDT method can inhibit the adenosine triphosphatase, which can damage subcellular apoptosis and necrosis of tumor cells. The majority of the photosensitizers localize in the cytosol, which includes the endoplasmic reticulum, mitochondria, lysosomes, and Golgi membranes (Juzenas *et al.*, 2001; Brancalion and Moseley, 2002; Allison *et al.*, 2004).

Should be energized that hydrolases and corrosive that break out of the harmed lysosomes likewise can debase cell added substances. At first, It changed into the idea that PS is confined to lysosomes (Serkies *et al.*, 2012; Rahat *et al.*, 2020). Hindrance of various mitochondrial proteins the most crucial one is cytochrome-c end up leaded through PDT From direct PDT conveyed on cell absence of existe Hypoxic tumor have been covered, as 1 O<sub>2</sub> arrangement is lacking with the helpful valuable guide of the way of O<sub>2</sub> accessibility. Diverse dosed of HeLa portable strains and a total thereof to look at adequacy with interceded (Karamzadeh *et al.*, 2001; Gallo *et al.*, 2001; Thakar *et al.*, 2000; Ullah *et al.*, 2021c). These training of most diseases are malignancy of tissues or pores and skin that covers our inward organs like gut, bosom, colon, lungs, and prostate tumors are known as carcinomas (Kreuzer *et al.*, 2000; Hinerman *et al.*, 2002; Lee *et al.*, 2007). Most malignancies start from the epithelium of the endometrial uterus. Ladies are the fourth most extreme reason for this

harm (Kennedy *et al.*, 1992; Khurshid *et al.*, 2010).

Many photosensitizers for PDT can be used. These are divided into porphyrins and dyes. Examples are Silicon phthalic and aminolevulinic acid (ALA) (Gallegos *et al.*, 1999; Atif *et al.*, 2009; De-CastroPazos *et al.*, 2003). Photosensitizers were available for medical use for therapeutical purposes in the field of PDT. These can also be encapsulated with nanoparticles for drug delivery (Yow *et al.*, 2007; Bednarz *et al.*, 2007; Khan *et al.*, 2021; Ullah *et al.*, 2020a). PDT turns on the intrinsic mechanism of mobile for its cell loss of lifestyles initiation through the manufacturing of cytochrome-c without up-law of inflammatory reaction. It has been stated that cell damages initiated via manner of apoptotic course strategies are massed an entire lot and lousy lot plenty tons much less dominant than initiated through necrosis. Morphological assessment for necrosis apoptosis confirmed that cytoplasm condenses which further triggers the disintegration of the cellular as an entire into the membrane-wonderful vesicles. The degradation approach is characterized through an intact feature of the membranes and the organelles, due to this minimum apoptosis, there may be an ordinary fragmentation of DNA Hypoxic tumors have been blanketed, as 1 O<sub>2</sub> formation is insufficient with the beneficial useful aid of manner of O<sub>2</sub> availability (Karu *et al.*, 1995). Different dosed of HeLa mobile strains and an aggregate thereof to examine effectiveness with mediated. This education of most cancers is cancer of tissues or pores and skin that covers our inner organs like belly, breast, colon, lungs, and prostate cancers are known as carcinomas. Most cancers originate from the epithelium of the endometrial uterus. Women are the fourth maximum cause of this malignancy (Dougherty *et al.*, 1998; Loschenov *et al.*, 2000; Solban *et al.*, 2006; Souza *et al.*, 2007).

Numerous photosensitizers for PDT can be utilized. These are isolated into porphyrins and colors. Models are Silicon phthalic and aminolevulinic corrosive (ALA). Photosensitizers were accessible for clinical use for the helpful reason in the field of PDT. These can likewise be embodied with nanoparticles with the end goal of medication conveyance. PDT turns on the natural component of portable for its phone loss of ways of life commencement through the assembling of cytochrome-c without up-law of provocative response. It has been expressed that cell harms started using way of apoptotic course methodologies are massed a whole part a terrible parcel bounty tons substantially less prevailing than started through corruption Morphological evaluation for putrefaction apoptosis affirmed that cytoplasm gathers which further triggers the deterioration of the cell as a whole into the layer brilliant vesicles. The debasement approach is portrayed through an unblemished element of the films and the organelles, because of this base apoptosis, there might be a customary fracture of DNA.

## Materials and Methods

The gear used in Photograph drug Exploration Research center in PIEAS were Biosafety Cupboard, CO<sub>2</sub> Hatchery, Trinocular Transformed Magnifying instrument, UV Spectrophotometer, Miniature well Plate Peruser, Radiation Source. Refined of Cutting-part the returned venture, Cells had been thoughtfully lifted on or after their course of energy vessel had been association excited on wells of a 96-well channel shameful plate, next conveying weapons inside the indistinguishable way as wanted to murder of instigation, chamber identity way were suspended initiating the dishonorable of the wells ahead of time than delicate desiring the use of a vacuum complex. The cells have been then washed with PBS, suctioned, and lysed inside the wells with the guide of the addition of cell extraction supports. HeLa upgraded with 10% fetal bovine serum, 2mM L-glutamine, 10 U/ml penicillin, and 10µg/ml streptomycin at 37°C with humidified natural components as a subjoined chamber sorted out from the beginning. Inside this connection, cells had been made, through the methodology for and tremendous farther than in their nearby made ordinary ecological elements. Corner nation natural factors gigantic farther than in their nearby made typical ecological components. Corner nation normal components were outstanding expected for all chamber make. monolayer in 25cm<sup>2</sup> tissue method of essence cup. The cell custom with 70-80% mix becomes accumulated by the use of 0.25% trypsin. HeLa cells were diffused in 96 well degrees lined microtiter plate at the thickness of 1×10<sup>5</sup> cells. For each charmingly. Cells have been given to four details that were hidden away at 37°C for 18 hrs. Human adenocarcinoma (HeLa) Cell line altered into delicate in 96-pleasantly microplate at a thickness of one hundred and 5 cells for each well keeping up in considerations the spare you reason to have a watch the plausible unsafe impact of laser mellow all alone. A semiconductor diode laser with a reasonable frequency. Culture plates have been shaken for 60 sec and left to remain at room temperature for 15 min. The absorbance of the solubilized shading changed along those follows check at 490 nm. Assessment of the disposed of shading ends up being related to the stay cell assortment.

Resulting in washing with phosphate support saline, 2 to 3 ml of trypsin have risen as acquainted with the flasks and cells were come gotten back to the incubator for a second and after that chose under a changed over amplifying gadget until what versatile layer has come to be scattered. After bringing forth the ideal time then their phone maintenance for 5-ALA has become anticipated at 405 nm mellow frequency utilizing a microwell plate. The phototoxic effect of laser slight on the Hep2c and HeLa cells altered into also decided. Culture has developed to be established inside the 96 pleasantly microtiter plate.

The plate altered into then acknowledged completing 70%-80% combination (watched through changed over amplifying focal point, inside the incubation center at 37°C for 24 hours to outline monolayer. HeLa cells have been given to laser slight at estimations inside the range from zero J/cm<sup>2</sup> to 160 J/cm<sup>2</sup> and 0 J/cm<sup>2</sup> to 100 J/cm<sup>2</sup> (4 wells steady with measurement) as I would like to think, without the development of photosensitizer.

The delicate media close by those follows cleared to region up gentle and replaced with a cutting edge 250µl MEM media and in some time plates had been come again to an incubator for resulting 24 hours in which the temperature adjusted into putting away at 37°C. Post agonizing the picture dangerous effect of laser mellow all alone is directed through utilizing reasonableness measure Cytotoxicity of 5-ALA on my Optimum five-ALA obsession for HeLa cells without flimsy effects develop as settled. The plates had been re agonized at 37°C for 7 hours and 18 hours as overhauled from the past exploratory impacts. Around the finish of incubation time, 5-ALA honed cells have been examined for the cell maintenance as an extended route because of the reality of the optical thickness of the utilization of microwell plate peruser with an optical channel of 405 nm frequency. This diverts is chosen considering the absorption frequency of the aminolevulinic destructive in cells and the cytotoxicity.

Cytotoxicity of five-ALA on my Optimum 5-ALA obsession for HeLa cells without temperamental influences rise as settled. HeLa cells were diffused because of this in a degree base method of ways of life plate on the pined for the thickness of one × 10<sup>4</sup> cells/ appropriately. In equal one control plate have developed to be similarly cause sorted out which to develop to be truly containing cells however now not provided to quiet. The plates were then set in the incubation facility at 37°C for twenty-4 hours allowing the cells to complete a 70%-80% converging monolayer.

At that component inside the accompanying degree now notoriety of 5-ALA has become varied for the two cell lines inside the extent of 0 – 1000µg/ml on a similar time as incubating have gotten done with the guide of their lovely assessments of seven hours for Hep2c and 18 hours for HeLa cell line this obsession was calculated through utilizing strategies for free red controlled inside the going with the way that every ubiquity develop to be directed to an extraordinary plate, no centers have been proper in a single plate. At that thing plates have been subsequently lit up with red moderate (635 nm PDT laser). Laser slight shaft changed into sent to the lower part of each pleasantly with the assistance of fiber to sparkle the cells paste to the good dividers.

Indeed, even as non-less expensive cells probably won't take in the tinge. After the cells had been popular

to pursue the shade they are quick washed or settled. The shade is then liberated from the cells in an aged ethanol alliance. An expansion or great purchase in the measure of cells comes around is related substitute inside the level of shading solidified with the valuable helpful asset of the cells inside the method of ways of life. The sensitive media near to those follows cleared to district up delicate and supplanted with a front line 250µl MEM media and in some time plates had been returned to a hatchery for coming about 24 hours in which the temperature changed into set aside at 37°C. Post anguishing the image risky impact of laser smooth isolated is coordinated through using sensibility measure Cytotoxicity of 5-ALA on my Ideal five-ALA fixation for Hela cells without wobbly impacts created as settled. The plates had been re-anguished at 37°C for 7 hours and 18 hours as upgraded from the past exploratory effects.

### Results and Discussion

The quantification of the up to get It to grow to be eminent that the PS absorbance will boom as with the increase of concentration. of PS. For every time c software language duration reading grow to be taken through micro nicely plate reader. It changed into said as showed inside the absorbance of PS will growth because of the truth the internalization time of PS will growth from 10-45 min then style adjustments and The PS Absorption Spectrum In Figure 1, the most absorbance spectra of photosets were recorded at 685 nm. The absorbance fashion represents that it may be used accurately in PDT because picture pinnacle lies in that variety (600-800 nM) it's therapeutically powerful. The popular curve as shown inside (Figure 3 and 4) changed into plotted with exceptional concentration of PS on the abscissa.

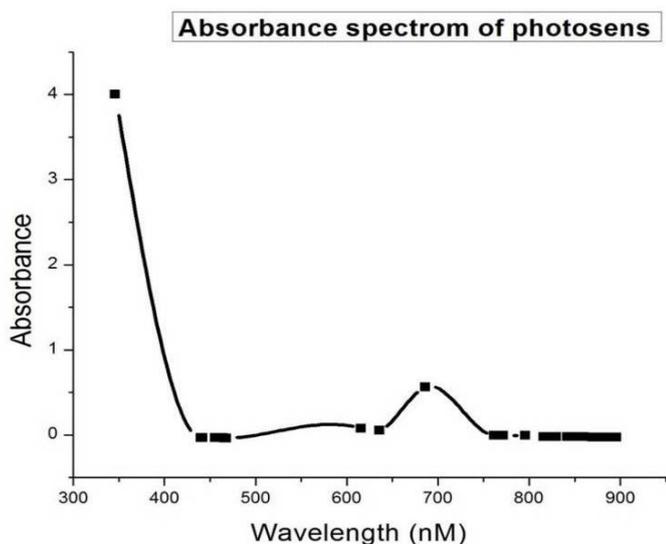


Figure 1: The Absorbance Spectrum of Photo sense.

In Figure 2, to get it to turn out it be mentioned that the PS absorbance will boom as with the PS concentration

increase. The obtained equation from the paragraph may be used for the quantification of PS. The internalization time of PS thru the cellular, solution of several concentrations. Ranging from 20, 30, 40, 50 and 70 µM had been organized and incubated with 15, 30, 45 and 1 hour time intervals. It grows to be noted that the absorbance of PS will increase as with the increase of hobby of PS. The equation acquired from the graph may be used for PS quantification because the internalization time is from 45-70 min. Absorbance started towards decline.

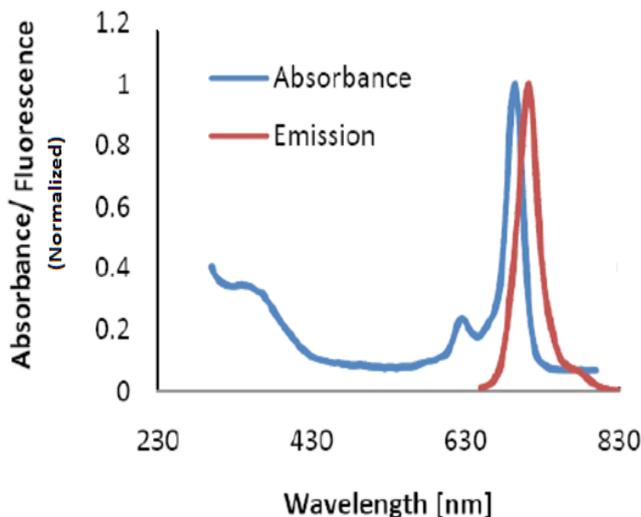


Figure 2: Spectrum of Phthalocyanine family.

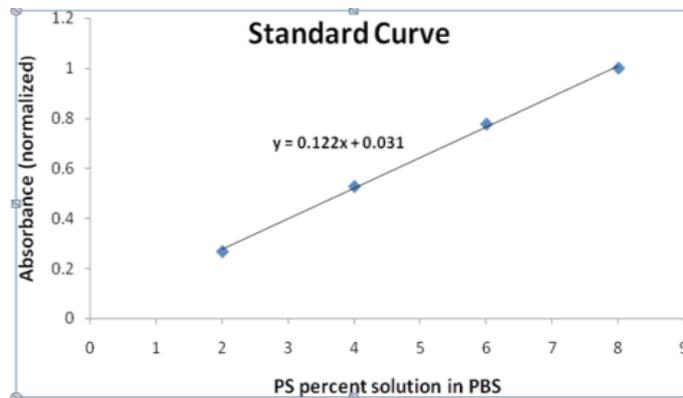


Figure 3: Standard curve of photosence.

The cellular line has to turn out to be incubated with various concentrations of PS for the finest uptake time of 45 mins. The cytotoxicity has become judged by way of manner of using the unbiased red assay. The most important hassle of cytotoxicity changed into to parent out the attention or shape of interest of PS having no or minimum cytotoxic outcomes, which can be used for PDT.

In Figure 5 the cytotoxicity at different concentrations most important hassle of cytotoxicity changed into to parent out the attention or shape of interest of PS having no or minimum cytotoxic outcomes, which can be used for PDT. The cease result is shown inside the (parent 4-5)

under which every records trouble represents a median SD of 4 information factors. The decide above represents that at low PS recognition (10µM ), an increase in mobile viability up to 110% emerges as mentioned. As the PS recognition changed into extended (from 15-25 µM) then the negligible cytotoxic effect of PS has ended up determined representing a lower fashion of % viability of Hela cells from one hundred to 97 %.

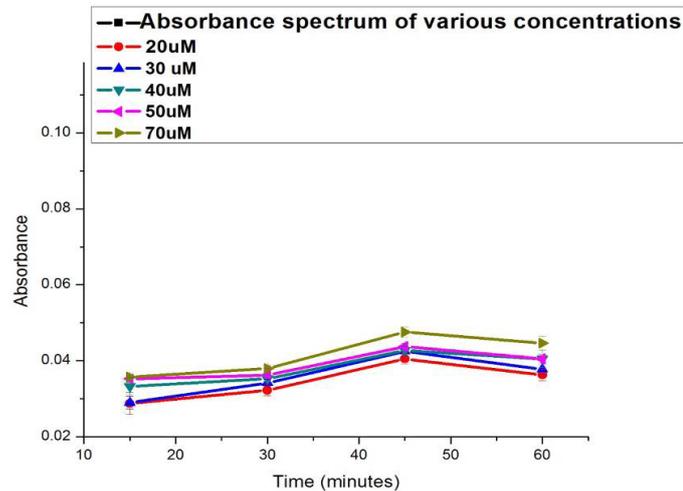


Figure 4: Absorbance spectrum of various concentrations.

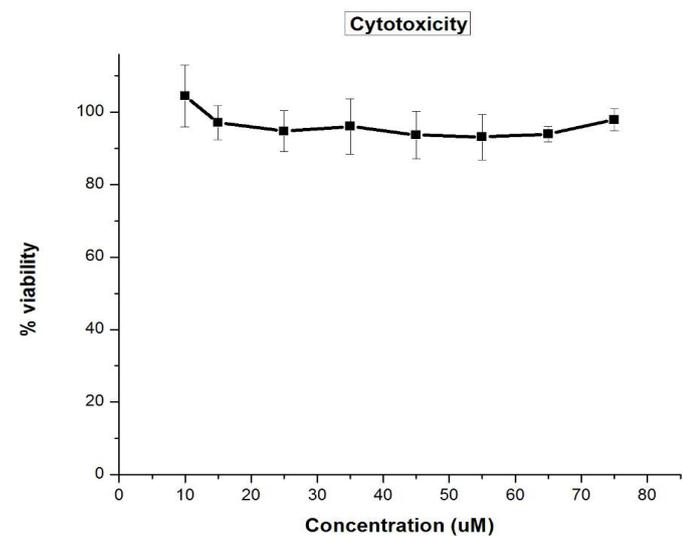


Figure 5: The cytotoxicity at different Photosense concentrations.

Results of phototoxicity can be seen in the figure below where each data point shows a mean of  $\pm\sigma$  (n=3).

In Figure 7 Phototoxicity at different Photosense concentrations At low doses starting from 5J/cm<sup>2</sup> to 100J/cm<sup>2</sup> the cell viability decreases nominally i.e. From a hundred % to 95%, showing that the mobile viability is stimulated very little at low doses without PS however this style changes at excessive doses beginning from one hundred J/cm<sup>2</sup> to 160 J/cm<sup>2</sup>, displaying that there may be lower in cell viability from 100% to 80%.

In Figure 6 the lethality was induced after 45 min following treatment of cells with light doses. Results of Invitro examine display that exquisite percent of cell loss of life of rhabdomyosarcoma cellular line following photosets mediated PDT has become definitely because of this motive that there was the most accumulation of photosens in the cells ensuing in 83.63% cell lack of life.

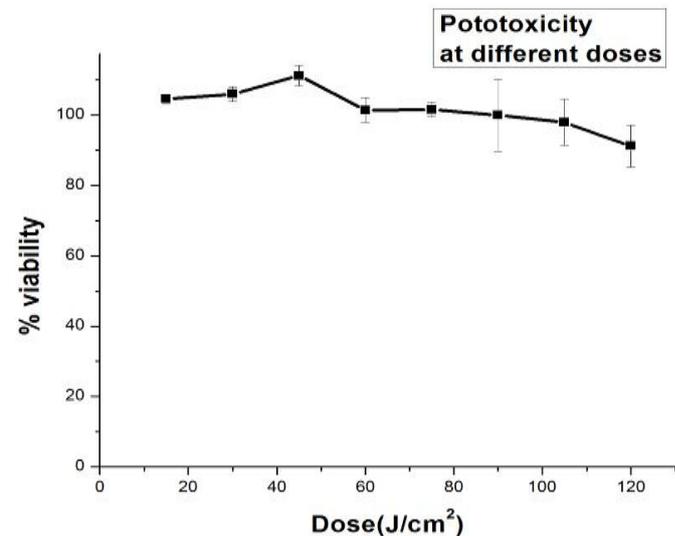


Figure 6: Phtotoxicity of different doses.

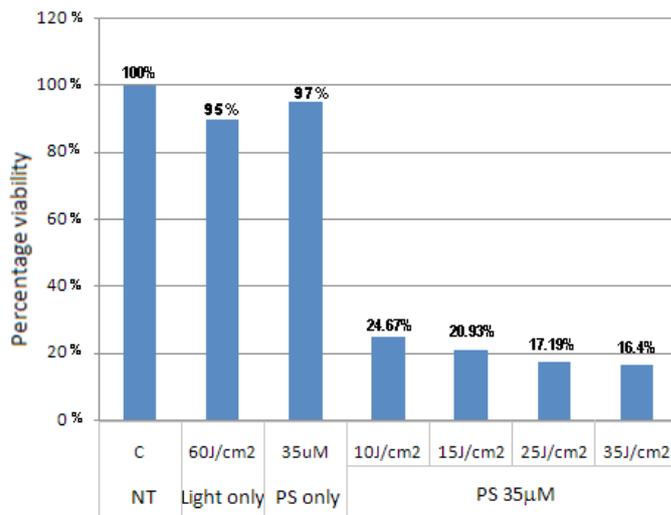


Figure 7: The lethality induced after 45 mints following treatment of cells with light doses.

The consequences of photosens mediated PDT in present take a look at reviled that cytotoxic effects of photosens on those cells were amount based regarding cognizance of photosens and depth set up concerning dose of the laser moderate.

It is high-quality to be conscious that % viability of those cells ends up extended up to 102% at very low PS (photosens) recognition of 5 micromolar (µM). It is awesome to be aware that % viability of these cells turns out to be prolonged up to 102% at very low PS (photosens) interest of 5 micromolar (µM). How is it viable and the

manner this exceptional style of extended viability can be)? This mechanism may be illustrated as that mitochondria are inspired to beautify the amount of adenosine triphosphate that is resulted in a boom in the number of reactive oxygen species, influencing bargain-oxidation (Redox) signaling, and also transcriptional factors are improved.

Photo sensitizer (Photosens) and biotinylated Photosens are multiple via the use of their amphiphilicity i.e. Having every hydrophilic and lipophilic home. As biotinylated Photosens have this capability that it may enter the mobile membrane pretty without problems, especially focused inner tumor cells, and initiate greater tumor damage which encompasses necrosis and apoptosis. To enhance the photodynamic effect, it's far advised that biotinilated photosens can be used in place of nonmodified photosense modified into utilized by our experimental paintings.

It has emerged as concluded that cytotoxic effect at unique concentrations of PS (Photosens) without laser mild.

Phototoxic effect of numerous slight doses without photosensitizer modified into almost negligible. They have a look at carried with Hela cells showed that if all the parameters like incubation time of image sensitizer, drug dose of photosensitizer, and laser moderate dose are optimized notably then maximum damage to cancerous cells may be completed efficiently (Luna *et al.*, 1991; Xu *et al.*, 2009).

It is an awesome candidate which absorbs mild powerfully inside the location of the seen spectrum which corresponds to the optical range as 600-800 nm. Into this purpose that it's miles poorly soluble in water and strongly inclined to form aggregates (Singh *et al.*, 1991; Mayhew *et al.*, 2001). This challenge of photosens can be resolved via Photodynamic remedy (PDT) includes a chemical response actuated via moderate electricity that is finished to especially damage tissue. The reaction calls for a photosensitizer in the purpose tissue, slight delivery, and oxygen. The most significantly examined photosensitizing stores for PDT are five-aminolevulinic corrosive for the remedy of actinic keratosis and methyl aminolevulinic which has been affirmed for the remedy of actinic keratosis basal cell carcinoma and Bowen's contamination. Not withstanding the nicely-installation conviction that maximum destructive to malignancy operators slaughter tumor cells through rot, ongoing discoveries have proven that photosensitizers need to likewise kill the tumor cells via the approach of apoptosis (Stewart *et al.*, 1998; Chen *et al.*, 2005).

On-time photosensitivity incited with using essential medicinal pills, the manner that a repair modified into functionality with using numerous extra practical

strategies and the lack of courses within the recovery writing ruined divulgation of this dermatological method till 1990 (Kennedy and Pottier, 1992). Protoporphyrin is an excessive photosensitizing agent and is degraded sooner or later by the radiation method with a particular slight supply. The presence of mild which modified the effect of the dye precipitated the distinguishing proof of a photosensitizer. In this manner, Professor von Tappeiner went earlier to complete one of a kind investigations and placed that the presence of oxygen ends up critical all collectively for the response to appear on this way making the term PDT (Peng *et al.*, 1996).

## Conclusions and Recommendations

Better doses of PS can also probably have unfavorable outcomes on wholesome cells. To reduce this limiting detail, PS may be encapsulated with nanoparticles. This approach can also furthermore moreover useful to reduce the dose of PS, even its uptake and retention time can be stepped forward within the intracellular area. This encapsulated low dose may additionally furthermore increase cancer cell killing. The effectiveness and efficacy of the PDT with photosens need to in addition be prolonged to awesome cell traces *in vitro*. The PDT consequences and efficacy for *in vivo* animal models.

### Conflict of interest

The authors have declared no conflict of interest.

## References

- Alexiades-Armenakas, M., 2006. Laser-mediated photodynamic therapy. *Clin. Dermatol.*, **24**: 16-25. <https://doi.org/10.1016/j.clindermatol.2005.10.027>
- Allison, R.R., Downie, G.H., Cuenca, R., Hu, X.H., Childs, C.J., and Sibata, C.H., 2004. Photosensitizers in clinical PDT. *Photodiagnosis photodyn. Ther.*, **1**: 27-42. [https://doi.org/10.1016/S1572-1000\(04\)00007-9](https://doi.org/10.1016/S1572-1000(04)00007-9)
- Atif, M., Firdous, S., Khurshid, A., Noreen, L., Zaidi, S.S.Z., and Ikram, M., 2009. *In vitro* study of 5-aminolevulinic acid-based photodynamic therapy for apoptosis in human cervical HeLa cell line. *Laser Phys. Lett.*, **6**: 886. <https://doi.org/10.1002/lapl.200910087>
- Bednarz, N., Zawacka-Pankau, J., and Kowalska, A., 2007. Protoporphyrin IX induces apoptosis in HeLa cells prior to photodynamic treatment. *Pharmacol. Rep.*, **59**: 474.
- Berek, J.S., and Hacker, N.F., 2005. *Practical gynecologic oncology*. Lippincott Williams and Wilkins.
- Bonnett, R., and Berenbaum, M., 1989. Porphyrins as photosensitizers. *Photosensit. Compounds*

- Chem., Biol. Clin. Use*, **146**: 40-53. <https://doi.org/10.1002/9780470513842.ch4>
- Brancaleon, L., and Moseley, H., 2002. Laser and non-laser light sources for photodynamic therapy. *Lasers Med. Sci.*, **17**: 173-186. <https://doi.org/10.1007/s101030200027>
- Cadron, I., Amant, F., and Vergote, I., 2005. Chemotherapy for cervical cancer. *Eur. Clin. Obstet. Gynaecol.*, **1**: 143-150. <https://doi.org/10.1007/s11296-005-0006-5>
- Chen, B., Pogue, B.W., Hoopes, P.J., and Hasan, T., 2005. Combining vascular and cellular targeting regimens enhances the efficacy of photodynamic therapy. *Int. J. Radiat. Oncol. Biol. Phys.*, **61**: 1216-1226. <https://doi.org/10.1016/j.ijrobp.2004.08.006>
- De-CastroPazos, M., Pacheco-Soares, C., Soares da Silva, N., DaMatta, R.A., and Pacheco, M.T.T., 2003. Ultrastructural effects of two phthalocyanines in CHO-K1 and HeLa cells after laser irradiation. *Biocell*, **27**: 301-309. <https://doi.org/10.32604/biocell.2003.27.301>
- Dougherty, T.J., Gomer, C.J., Henderson, B.W., Jori, G., Kessel, D., Korbek, M., and Peng, Q., 1998. Photodynamic therapy. *J. natl. Cancer Inst.*, **90**: 889-905. <https://doi.org/10.1093/jnci/90.12.889>
- Gallegos, E.R., Rodríguez, I.D., Guzmán, L.A.M., and Zapata, A.J.P., 1999. *In vitro* study of biosynthesis of protoporphyrin IX induced by  $\delta$ -aminolevulinic acid in normal and cancerous cells of the human cervix. *Arch. Med. Res.*, **30**: 163-170. [https://doi.org/10.1016/S0188-0128\(99\)00013-5](https://doi.org/10.1016/S0188-0128(99)00013-5)
- Gallo, A., Moi, R., Simonelli, M., Vitolo, D., Fiorella, M.L., Marvaso, V., and De Vincentiis, M., 2001. Salvage resection after previous laryngeal surgery: Total laryngectomy with en bloc resection of the overlying cervical skin. *Arch. Otolaryngol. Head Neck Surg.*, **127**: 786-789.
- Hinerman, R.W., Mendenhall, W.M., Amdur, R.J., Villaret, D.B., and Robbins, K.T., 2002. Early laryngeal cancer. *Curr. Treat. Opt. Oncol.*, **3**: 3-9. <https://doi.org/10.1007/s11864-002-0036-x>
- Hreshchyshyn, M.M., Aron, B.S., Boronow, R.C., Franklin III, E.W., Shingleton, H.M., and Blessing, J.A., 1979. Hydroxyurea or placebo combined with radiation to treat stages IIIB and IV cervical cancer confined to the pelvis. *Int. J. Radiat. Oncol. Biol. Phys.*, **5**: 317-322. [https://doi.org/10.1016/0360-3016\(79\)91209-4](https://doi.org/10.1016/0360-3016(79)91209-4)
- Juzenas, P., Iani, V., Bagdonas, S., Rotomskis, R., and Moan, J., 2001. Fluorescence spectroscopy of normal mouse skin exposed to 5-aminolaevulinic acid and red light. *J. Photochem. Photobiol. B Biol.*, **61**: 78-86. [https://doi.org/10.1016/S1011-1344\(01\)00149-X](https://doi.org/10.1016/S1011-1344(01)00149-X)
- Karamzadeh, A.M., and Armstrong, W.B., 2001. Aquatic activities after total laryngectomy. *Otolaryngol. Head Neck Surg.*, **125**: 528-532. <https://doi.org/10.1067/mhn.2001.119323>
- Karu, T., Pyatibrat, L., and Kalendo, G., 1995. Irradiation with He-Ne laser increases ATP level in cells cultivated *in vitro*. *J. Photochem. Photobiol. B Biol.*, **27**: 219-223. [https://doi.org/10.1016/1011-1344\(94\)07078-3](https://doi.org/10.1016/1011-1344(94)07078-3)
- Kennedy, J.C., and Pottier, R.H., 1992. New trends in photobiology: Endogenous protoporphyrin IX, a clinically useful photosensitizer for photodynamic therapy. *J. Photochem. Photobiol. B Biol.*, **14**: 275-292. [https://doi.org/10.1016/1011-1344\(92\)85108-7](https://doi.org/10.1016/1011-1344(92)85108-7)
- Khan, A., Umhang, G., Ullah, Z., Boué, F., Bastid, V., Ullah, I., and Ahmed, H., 2021. Investigation of Echinococcus multilocularis in foxes and dogs in Pakistan by detection of copro-DNA. *Parasitol. Res.*, **120**: 731-737. <https://doi.org/10.1007/s00436-020-07001-x>
- Khurshid, M., Atif, S., Firdous, R., Salman, S.S.Z., Zaidi, M., Ikram, Khursid, A., Atif, M., Firdous, S., Zaidi, S.S.Z., Salman, R., and Ikram, M., 2010. Study of the efficacy of 5 ALA-mediated photodynamic therapy on human larynx squamous cell carcinoma (Hep2c) cell line. *Laser Phys.*, **20**: 1673-1678. <https://doi.org/10.1134/S1054660X10130086>
- Kretmer-Birnbaum, M., 1989. Modified porphyrins, chorins, phthalocyanines, and purpurines: Second generation photosensitizers for photodynamic therapy. *Semin Hematol.*, **26**: 157-173.
- Kreuzer, S.H., Schima, W., Schober, E., Pokieser, P., Kofler, G., Lechner, G., and Denk, D.M., 2000. Complications after laryngeal surgery: videofluoroscopic evaluation of 120 patients. *Clin. Radiol.*, **55**: 775-781. <https://doi.org/10.1053/crad.2000.0517>
- Lee, J.H., Sun, D., Cho, K.J., Kim, M.S., Hong, M.H., Kim, I.K., and Lee, J.H., 2007. Overexpression of human 27 kDa heat shock protein in laryngeal cancer cells confers chemoresistance associated with cell growth delay. *J. Cancer Res. Clin. Oncol.*, **133**: 37-46. <https://doi.org/10.1007/s00432-006-0143-3>
- Loschenov, V.B., Konov, V.I., and Prokhorov, A.M., 2000. Photodynamic therapy and fluorescence diagnostics. *Laser Phys. Lawrence*, **10**: 1188-1207.
- Luna, M.C., and Gomer, C.J., 1991. Isolation and initial characterization of mouse tumor cells resistant to porphyrin-mediated photodynamic therapy. *Cancer Res.*, **51**: 4243-4249.
- Ma, L., Bagdonas, S., and Moan, J., 2001. The photosensitizing effect of the photoproduct of

- protoporphyrin IX. *J. Photochem. Photobiol. B Biol.*, **60**: 108-113. [https://doi.org/10.1016/S1011-1344\(01\)00133-6](https://doi.org/10.1016/S1011-1344(01)00133-6)
- Mayhew, S., Vernon, D.I., Schofield, J., Griffiths, J., and Brown, S.B., 2001. Investigation of cross-resistance to a range of photosensitizers, hyperthermia and UV light in two radiation-induced fibrosarcoma cell strains resistant to photodynamic therapy *in vitro*. *Photochem. Photobiol.*, **73**: 39-46. [https://doi.org/10.1562/0031-8655\(2001\)073<0039:IOC RTA>2.0.CO;2](https://doi.org/10.1562/0031-8655(2001)073<0039:IOC RTA>2.0.CO;2)
- Peng, Q., Moan, J., and Nesland, J.M., 1996. Correlation of subcellular and intratumoral photosensitizer localization with ultrastructural features after photodynamic therapy. *Ultrastruct. Pathol.*, **20**: 109-129. <https://doi.org/10.3109/01913129609016306>
- Rahat, M.A., Haris, M., Ullah, Z., Ayaz, S.G., Nouman, M., Rasool, A., and Israr, M., 2020. Domestic animals' identification using PCR-RFLP analysis of cytochrome b gene. *Adv. Life Sci.*, **7**: 113-116.
- Serkies, K., Dziadziuszko, R., and Jassem, J., 2012. Continuous 7 days a week external beam irradiation in locally advanced cervical cancer: Final results of the phase I/II study. *Int. J. Radiat. Oncol. Biol. Phys.*, **82**: 1256-1261. <https://doi.org/10.1016/j.ijrobp.2010.11.065>
- Sharkey, S.M., Wilson, B.C., Moorehead, R., and Singh, G., 1993. Mitochondrial alterations in photodynamic therapy-resistant cells. *Cancer Res.*, **53**: 4994-4999.
- Singh, G., Wilson, B.C., Sharkey, S.M., Browman, G.P., and Deschamps, P., 1991. Resistance to photodynamic therapy in radiation induced fibrosarcoma-1 and Chinese hamster ovary-multi-drug resistant cells *in vitro*. *Photochem. Photobiol.*, **54**: 307-312. <https://doi.org/10.1111/j.1751-1097.1991.tb02021.x>
- Solban, N., Rizvi, I., and Hasan, T., 2006. Targeted photodynamic therapy. *Lasers Surg. Med. Off. J. Am. Soc. Laser Med. Surg.*, **38**: 522-531. <https://doi.org/10.1002/lsm.20345>
- Souza, C.S., Neves, A.B., Felicio, L.A., Ferreira, J., Kurachi, C., and Bagnato, V.S., 2007. Optimized photodynamic therapy with systemic photosensitizer following debulking technique for nonmelanoma skin cancers. *Dermatol. Surg.*, **33**: 194-198. <https://doi.org/10.1111/j.1524-4725.2006.33038.x>
- Stehman, F.B., Bundy, B.N., Thomas, G., Keys, H.M., d'Ablaing, G., Fowler, W.C., and Creasman, W.T., 1993. Hydroxyurea versus misonidazole with radiation in cervical carcinoma: Long-term follow-up of a gynecologic oncology group trial. *J. Clin. Oncol.*, **11**: 1523-1528. <https://doi.org/10.1200/JCO.1993.11.8.1523>
- Stewart, F., Baas, P., and Star, W., 1998. What does photodynamic therapy have to offer radiation oncologists (or their cancer patients)? *Radiother. Oncol.*, **48**: 233-248. [https://doi.org/10.1016/S0167-8140\(98\)00063-2](https://doi.org/10.1016/S0167-8140(98)00063-2)
- Thakar, A., Bahadur, S., Mohanti, B.K., and Nivsarkar, S., 2000. Clinically staged T3N0M0 laryngeal cancer: how is it best treated? Definitive radiotherapy with salvage surgery v/s combined surgery and radiotherapy. *J. Laryngol. Otol.*, **114**: 108-112. <https://doi.org/10.1258/0022215001905030>
- Ullah, Z., Ullah, I., Ullah, I., Mahmood, S., and Iqbal, Z., 2020a. Poaching of Asiatic black bear: evidence from Siran and Kaghan valleys, Pakistan. *Glob. Ecol. Conserv.*, **24**: e01351. <https://doi.org/10.1016/j.gecco.2020.e01351>
- Ullah, Z., Mahmood, S., Iqbal, Z., Khan, J., Akhtar, N., Khan, M.A., and Yasmin, S., 2021b. Habitat selection by Asiatic black bear (*Ursus thibetanus*) in Siran and Kaghan Valleys, Pakistan. *Braz. J. Biol.*, **83**. <https://doi.org/10.1590/1519-6984.247890>
- Ullah, Z., Sajid, M., Iqbal, Z., Akhtar, N., Khan, G.B., Ali, A., and Arif, M., 2021c. Movement of asiatic black bear: sign survey evidence from Kaghan and Siffran Valleys, Pakistan. *Biosci. Res.*, **18**: 1433-1445.
- Ullah, Z., Mahmood, S., Iqbal, Z., Akhtar, N., Khan, M.F., Said, A., and Arif, M., 2021d. Damages to Himalayan white pine (*Pinus wallichiana*) by asiatic black bear (*Ursus thibetanus*) in Kaghan Valley, Pakistan. *Forests*, **12**: 1130. <https://doi.org/10.3390/f12081130>
- Woodburn, K.W., Fan, Q., Kessel, D., Luo, Y., and Young, S.W., 1998. Photodynamic therapy of B16F10 murine melanoma with lutetium texaphyrin. *J. Invest. Dermatol.*, **110**: 746-751. <https://doi.org/10.1046/j.1523-1747.1998.00182.x>
- Xu, C.S., and Leung, A.W.N., 2009. Light-activated hypericin induces cellular destruction of nasopharyngeal carcinoma cells. *Laser Phys. Lett.*, **7**: 68. <https://doi.org/10.1002/lapl.200910095>
- Yow, C.M.N., Wong, C.K., Huang, Z., and Ho, R.J., 2007. Study of the efficacy and mechanism of ALA-mediated photodynamic therapy on human hepatocellular carcinoma cell. *Liver Int.*, **27**: 201-208. <https://doi.org/10.1111/j.1478-3231.2006.01412.x>
- Zamora-Juárez, Y., Pérez-Zapata, A.J., Rodríguez, L.S., Ramon-Gallegos, E., and Cruz-Orea, A., 2005. Photodynamic effect of modulated and continuous LASER radiation on cancerous cells cultivated *in vitro*. *Phys. Scr.*, **2005**: 136. <https://doi.org/10.1238/Physica.Topical.118a00136>