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# The Assessment of the Effect of Laser Irradiation on Paracetamol Solutions

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**Abstract**

The rapid development in laser technology and the understanding of its applications and biological reactions have contributed to broadening new horizons in the field of drug treatment. In this study, an aqueous solution with a concentration of 1 M was subjected to a diode laser with a wavelength of 808 nm and a power of 1 W. This solution was exposed to the laser for three different periods: 10, 15, and 20 seconds, with the sample fixed at a distance of 10 cm. Studying some of the optical properties of the solution revealed that its absorbance increased by 3.5% at the longest laser exposure period. This led to enhancing the qualitative characteristics of the drug used.

## Introduction

Paracetamol, a painkiller is a common drug prescribed to relieve aches and lower high temperatures [1,2,3]. The paracetamol significance is due to its efficacy in many analgesic products. These products include painkillers used to relieve arthritis, neurospasms [4,5,6], and fever. Figure 1 shows the chemical structure of paracetamol. Generally, if it is used fairly, it is safe to reach 4 mg daily. However, excessive use of the drug may cause renal and hepatic impairments due to unhealthy metabolite buildups like N-acetyl-p-benzoquinone imine and p-benzoquinone imine [7,8].

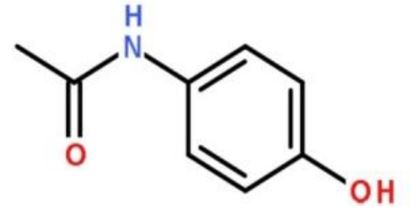


**Figure 1:** Chemical Structure of Paracetamol.

Sensitive and accurate methods of detecting radiation, such as mass spectrometry, titration, and electrophoretic liquid chromatography, typically need specialized medical care procedures, costly apparatus and instruments, and constant analyses [9]. Due to the significant advancements in the use of diode lasers, which have been observed in nearly all fields of science, several diode lasers have been developed. This has, in turn, broadened the horizons for numerous new research methods. Many systems used today depend on diode lasers, including atomic and molecular spectrophotometry, interference, enhancement of frequency standards, measurements, atomic optics, optical communications, material testing, process control, atmospheric chemistry, and healthcare uses. These systems benefit from diode lasers' excellent properties, such as low energy consumption and reasonable costs [10,11]. All diode laser-dependent techniques and assessment methods, starting with laboratory research to automotive as well as industrial fields, are constantly evolving [12]. Furthermore, diode lasers are used in medical treatments due to their anti-inflammatory, antimicrobial, and analgesic effects. They also demonstrate nonthermal and bio-stimulatory effects [13]. Diode lasers are utilized in the pharmaceutical industry as numerous studies have confirmed their significant role in enhancing and developing painkillers. Atabak et al. showed that selective laser sintering (SLS) is a direct, affordable, and adaptive 3D printing technique that can be used for decentralized commercial production of customized dosage forms. This is due to the laser's flexibility and ability to accurately customize the active dose of paracetamol. It also allows for the design, shaping, and printing of several drugs in a single dose [14].

In addition, Yanis et al produced solid oral dosage forms (SODFs) using copovidone and paracetamol using SLS. Testing showed that the drug has not been degraded throughout sintering, even with the extreme power of the laser. Thereby a novel approach in research fields utilizing such printers to produce SODFs [15]. However, Shatton et al. used a new laser method to detect changes in pain threshold after taking a low dose of paracetamol and detect whether the active dissolved shape produces a rapid action start compared to the solid shape [16]. Several studies have been conducted on the possibility of obtaining faster efficacy of paracetamol. It was shown that the liquid form of paracetamol has a faster onset of action than tablets. Furthermore, Rygnestad et al. have found that a single oral of effervescent paracetamol tablets was rapidly absorbed in healthy volunteers compared to regular paracetamol tablets dose [17].

A study by Lee et al. showed that a hot drink of paracetamol was absorbed more quickly and in greater amounts compared to tablets [18]. Ali et al. found that taking the recommended doses of paracetamol combined with caffeine resulted in a much more effective and rapid action start than the regular tablet, while also being safe [19]. This work aims to use laser radiation to increase the absorption rate and efficacy of an aqueous paracetamol solution.

## Materials and Methods

An aqueous solution with a concentration of 0.1 M was obtained by mixing 1.5117 g of paracetamol samples in 100 mL of D.W. This solution was then divided into four groups, three of which were irradiated with an 808 nm IR wavelength and a power of 1.5 W. The groups were exposed to the laser for 10, 15, and 20 seconds, respectively, at a distance of 10 cm from the laser source. To assess the efficacy of laser irradiation on the optical characteristics of the samples, they were subjected to UV and FTIR testing.

## Results and Discussion

The results of UV-visible spectroscopy demonstrate the effect of laser radiation on the paracetamol solution when exposed over three different periods. Figure 2 shows the absorption spectra of the paracetamol solution before and after laser irradiation. The 20-second exposure caused a significant increase in the paracetamol solution absorption rate by approximately 3.5%, along with a shift in its peak absorption wavelength towards higher wavelengths, which enhanced the reaction. Moreover, increasing the duration of laser exposure raises the temperature of the solution, thereby accelerating its pharmacological effect, as supported by the studies mentioned earlier [20].

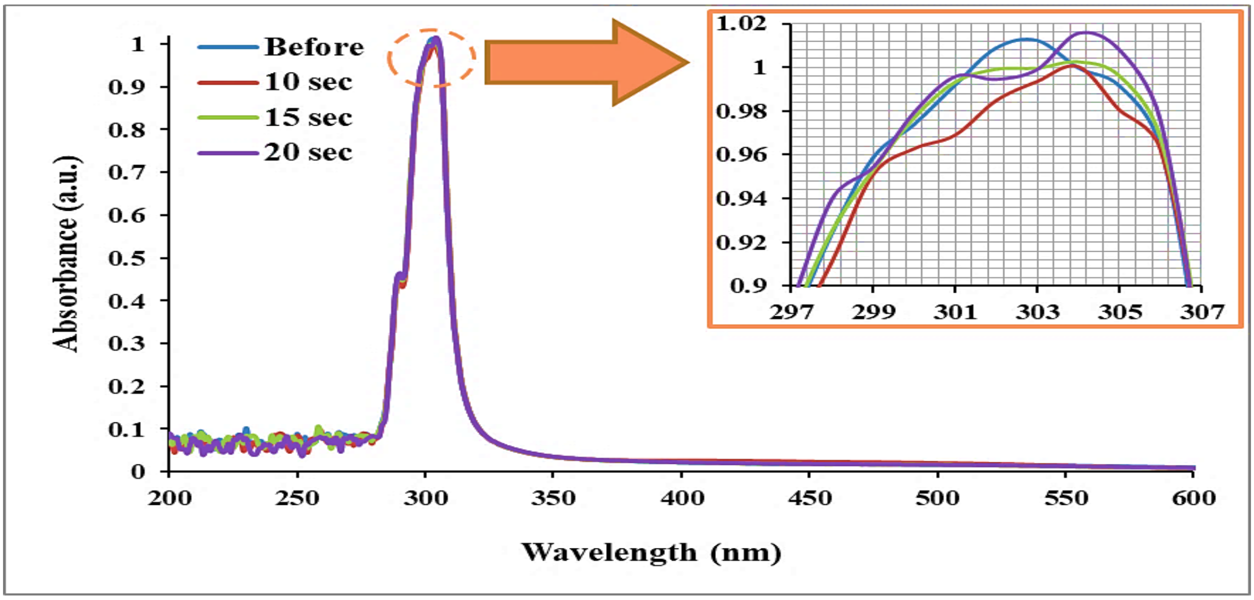


**Figure 2:** Paracetamol Absorbance Spectra before and after Laser Irradiation

Another optical property change observed in the paracetamol solution is the transmittance spectrum, as shown in Figure 3. The transmittance values of the solution decrease at shorter wavelengths, reaching their lowest point at the wavelength corresponding to the highest absorbance value. After this point, the transmittance increases toward the visible wavelengths and then remains nearly constant. The transmittance curve exhibits behavior opposite to that of the absorbance curve.

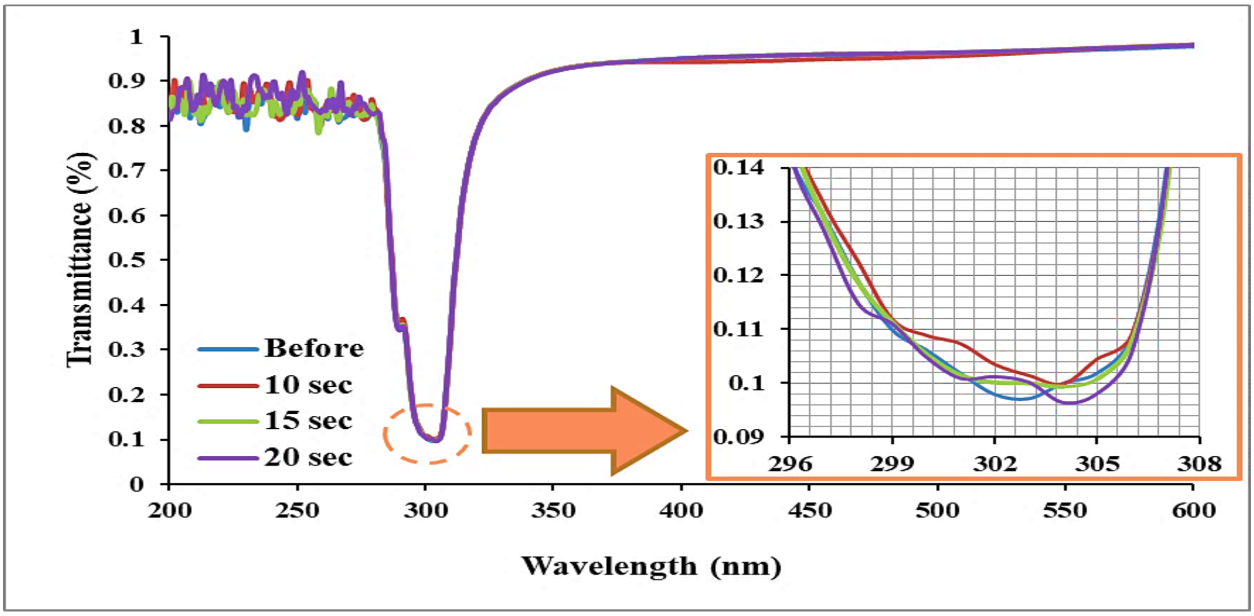


**Figure 3:** Paracetamol Transmittance Spectra before and after Laser Irradiation

The absorption coefficient of the paracetamol solution was also calculated as the rest of the optical constants. It determines the amount of absorbance of a specific wavelength of the light that penetrates the solution. In other words, it describes the amount of light of a particular color that is absorbed by the solution with a specific thickness. The thickness, or path length (t), through which the light passes inside the paracetamol solution is 1 cm, corresponding to the dimensions of the glass cuvette used in the UV-visible spectrometer.

Figure 4 shows the absorption coefficient curves (α) for the paracetamol solution before and after laser irradiation, indicating that the 20-second irradiation caused a slight shift in the wavelength corresponding to the absorption coefficient value from 303 nm to 3.4 nm and an increase in the absorption coefficient value by about 0.01 after irradiation. The absorption coefficient value is directly proportional to the absorbance (A) according to equation (1) [20]:

$\alpha = 2.303A/t$ ... (1).

The analysis of active groups in paracetamol solutions before and after laser exposure was conducted using Fourier-transform infrared (FTIR) spectroscopy. Figure 4 demonstrates the typical vibration bands for paracetamol solutions present in all four spectra before and after laser laser irradiation. These bands include; the carbonyl amide group (NH-C=O) band at 1650 $cm^{-1}$, the aromatic (C-H) group band at 3000 $cm^{-1}$, the (N-H) group band at 3200 $cm^{-1}$, and the phenolic (O-H) group band at 3410 $cm^{-1}$. These bands became more pronounced after the irradiation, especially in the solution exposed to the 20-second irradiation period [21, 22]. The carbonyl amide band became sharp. The phenolic hydroxyl band, on the other hand, appeared wider, indicating increased bond vibrations in the paracetamol compound. This increase in bond vibrations increases the speed of the pharmacological effect of paracetamol, as indicated by the studies mentioned earlier [23].

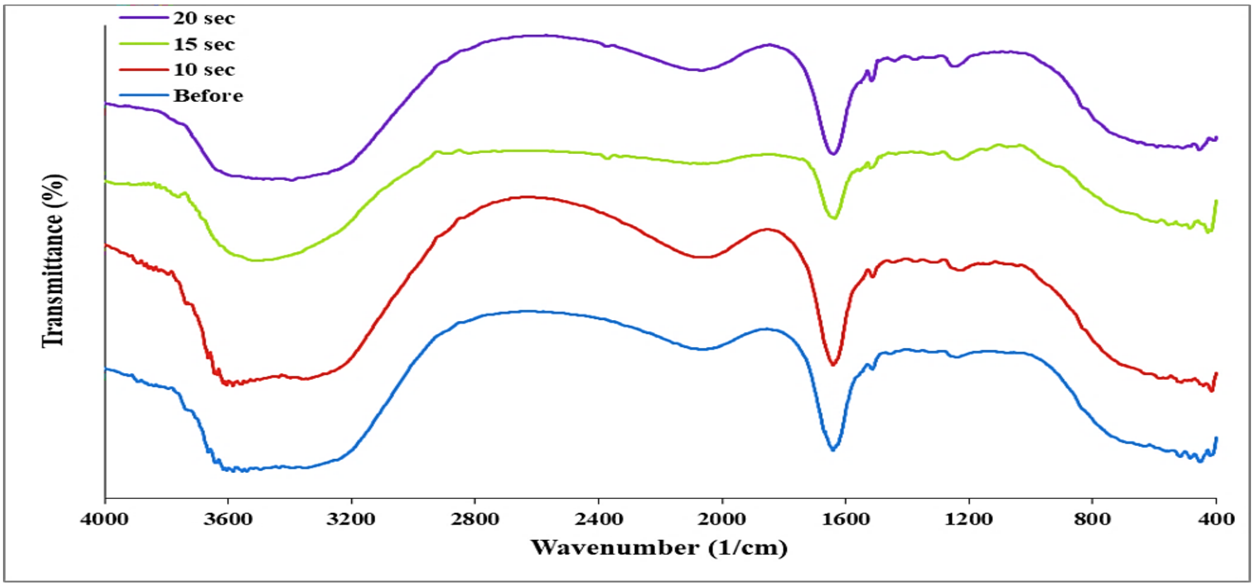


**Figure 4:** FTIR Analysis of Paracetamol before and after Laser Irradiation.

## Conclusions

Laser processing of materials, including medical drugs, enhances their properties. It is a safe, cost-effective, and efficient method, providing significant heat to the target without requiring a high energy input. This study has highlighted the impact of laser radiation on the absorption, permeability, and active groups of paracetamol solutions. Laser exposure alters the intensity of the drug's optical properties curve, indicating changes in its crystallinity, particularly with longer exposure times, as absorption increased by approximately 3.5%. Therefore, it is concluded that the absorption characteristics of paracetamol can be improved by extending the laser exposure period.

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## Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author (Duaa Naseer Abdul Hameed) used [ChatGPT and Grammarly] to [linguistic and grammar checking]. After using ChatGPT and Grammarly, the author reviewed and edited the content as needed and took full responsibility for the publication's content.

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# تقييم تأثير أشعه الليزر على محاليل الباراسيتمول

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**الخلاصة:**

لقد ساهم التطور السريع في تكنولوجيا الليزر وفهم تطبيقاته وتفاعلاته البيولوجية في توسيع آفاق جديدة في مجال علاج الأدوية، وفي هذه الدراسة تم تعريض محلول مائي بتركيز 1M لليزر ثنائي بطول موجي 808 نانومتر وقوة (1) واط ,وقد تعرض المحلول لليزر لمدة ثلاث فترات مختلفة: (10,15,20) ثانية، مع تثبيت العينة على مسافة 10 cm، وقد أظهرت دراسة بعض الخصائص البصرية للمحلول أن امتصاصه زاد بنسبة 3.5% عند أطول فترة تعرض لليزر، مما أدى إلى تعزيز الخصائص النوعية للدواء المستخدم.