

Dedication

I dedicate this thesis

To

my father and
mother ,

my family
and

whom

love me .

Rasha

Acknowledgment

I would like to express my deep gratitude and sincere thanks to my supervisor Dr. Mubarak ElMahal Ahmed.

Deep thanks to Prof. Nafie Abdellateef who taught me the value of sacrifices. Without him this work would be difficult if not

impossible. My thank falls short to his great help and kind guidance.

And I thank the staff of the Institute of Laser in Sudan University of Science and Technology who I found them as my second family.

Thanks are extended to all my friends for their invaluable help.

Abstract

In this work a simple setup was build to measure the angular scattering of laser light to test the quality of some medical solutions (concentration) and detect any change in the concentration from the standard concentration which must be suitable for desired dose.

In this setup diode laser with wavelength 671 nm and output power 100 mW and photomultiplayer tube were used to find the relation between sample concentration and transmitted intensity at zero angle, and scattered intensities at angles 45° , 90° and 135° for the following samples:

Sugar and Sodium Chloride (NaCl) as standard samples, to calibrate the setup and to study the behavior of the scattered light, and other targeted samples: Benzylpenicillin Sodium (BS), Metronidazole and Actrapid HM (Insulin Human) (IH).

The results showed that the relation between the transmitted intensity and sample concentration is inverse linear relation. Also, the relation between the angular scattered intensity and sample concentration is linear relation.

The study proved that, this setup is very sensitive to detect the scattered laser intensity at any change in sample concentration from its standard concentration. It was found that, a change in the concentration of BS sample, as example by (0.04), the setup gave clear reading of this change. Also, a change in the concentration of (IH) sample by (0.025) gave clear differences in scattered intensity at all angles for this very little change.

From the characteristics mentioned above it is clear that, this setup is very efficient in discovering any manipulation in the drug dose.

المستخلص

تم في هذه الدراسة بناء وإختبار منظومة بسيطة وفعالة ودقيقة لقياس التشتت الزاوي لضوء الليزر وذلك لفحص جودة بعض المحاليل الطبية (من حيث التركيز) واكتشاف أي تغيير في التركيز عن التركيز القياسي الذي يفترض أن يكون مناسباً للجرعة المطلوبة .

استخدم في هذه المنظومة ليزر الثنائي ذي الطول الموجي 671 نانومتر وبقدرة 100 ملي واط وكاشف المضاعف الضوئي لإيجاد العلاقة بين تركيز العينة والشدة النافذة بالزاوية (0) والشدة المتشتتة بالزاوية (135,90,45) كل على حده لكل من

العينات التالية: السكر والملح بإعتبارهما عينات معيارية لهذا البحث، وبقيّة العينات المستهدفة هي: البنسلين، الفلاجيل و الأنسولين وبتراكيز مختلفة.

بينت نتائج هذه الدراسة أن الشدة النافذة تتناسب عكسياً مع تركيز العينة، أي أنه كلما زاد تركيز العينة قلت الشدة النافذة والعكس بالعكس. وأن الشدة المتشتتة زاوياً تتناسب طردياً مع تركيز العينة، أي أنه كلما زاد تركيز العينة زادت الشدة المتشتتة والعكس بالعكس.

أثبتت الدراسة أن المنظومة غاية في الدقة لتحسس شدة الليزر المتشتتة لأقل تغيير في تركيز العينات عما كان عليه تركيزها القياسي، فلا قد وجد أن عند تغيير التركيز في عينة البنسلين مثلاً بمقدار (0.04)) أعطت المنظومة قراءات واضحة لهذا التغيير. كما وجد أنه عند تغيير تركيز عينة الأنسولين بمقدار (0.025) أيضاً أعطت المنظومة فروقات واضحة في الشدة المتشتتة وبكل الزوايا عند هذا التغيير البسيط جداً.

من هنا يتضح أن هذه المنظومة قادرة على فحص جودة المحاليل الطبية من حيث تركيزها و اكتشاف أي تلاعب في التركيز مهما قل عن التركيز القياسي.

Contents

Dedication	i
Acknowledgement	ii
Abstract	iii

Abstract

.....iv

Contents.....

..v

Chapter One: Basic Concepts

1-1 Introduction	1
1-2 Definition of Laser	2
1-3 Energy Levels	2
1-4 Absorption of Radiation	5
1-5 Spontaneous Emission of Radiation	6
1-6 Stimulated Emission of Radiation	8
1-7 Population Inversion	9
1-8 Threshold Condition	11
1-9 Basic Elements of Laser System	12
1-9-1 Active Medium	12
1-9-2 Excitation Mechanism	13
1-9-3 Feedback Mechanism	13
1-9-4 Output Coupler	14
1-10 Properties of Laser Light	14
1-10-1 Monochromaticity	15
1-10-2 Directionality	15
1-10-3 Coherence	16
1-11 Types of lasers	16
1-11-1 Solid State Lasers	16
1-11-2 Gas Lasers	16
1-11-3 Dye Lasers	17
1-11-4 Semiconductor Lasers	18
1-12 Laser Safety	18

1-13 Laser Spectroscopy	20
1-13-1 Spectroscopy	20
1-13-2 Uses of Laser Spectroscopy	20
1-13-3 Types of Laser Spectroscopy	21
1-13-3-1 Laser Absorption Spectroscopy	22
1-13-3-2 Laser Raman Spectroscopy	24
1-14 Applications of Laser Spectroscopy	26
1-14-1 Applications in Chemistry	26
1-14-2 Applications in Environmental Research	27
1-14-3 Applications in Technical Problems	28
1-14-4 Applications in Biology	28
1-14-5 Medical Applications	28

Chapter Two: Light Scattering Theory

2-1 Introduction	30
2-2 Light Matter Interaction	31
2-2-1 Refraction and Dispersion.....	32
2-2-2 Absorption and Emission	35
2-3 Light Scattering Processes	37
2-4 Types of Light Scattering	39
2-4-1 Elastic Scattering	40
2-4-1-1 Rayleigh Scattering	40
2-4-1-2 Mie Scattering	42
2-4-2 Inelastic Scattering	42
2-4-2-1 Raman Scattering	43
2-4-2-2 Brillouin scattering	45
2-4-3 Angular Scattering	46
2-5 Angular Distributions of Light Scattering	47

2-5-1 Angular Distributions Dependence on Particle Size and Refractive Index.....	47
2-5-2 Angular Distributions Dependence on the Number of Particles	48
2-5-3 Angular Distributions Dependence on the Angle of Observation	48
2-6 Scattering Measuring Techniques	49
2-6-1 Static Light Scattering (SLS).....	50
2-6-1-1 The Debye plot	55
2-6-2 Dynamic light scattering (DLS)	57
2-7 Light-scattering instrumentation	57
2-8 Aim of the work	58

Chapter Three: Experimental Part

3-1 Introduction	59
3-2 Experimental Setup	59
3-2-1 Diode Laser	60
3-2-2 Sample Chamber	61
3-2-2-1 Sample Cell	63
3-2-3 Photomultipliers Tube (PMT)	63
3-2-4 Digital Multimeter.....	65
3-3 The Samples	65
3-3-1 Sample No (1): Dextrose (Sugar)	65
3-3-2 Sample No (2): Sodium Chloride (NaCl)	66
3-3-3 Sample No (3): Benzylpenicillin Sodium.....	66
3-3-4 Sample No (4): Metronidazole Intravenous Infusion	67
3-3-5 Sample No (5): Actrapid HM (Insulin Human)	67
3-3-6 Sample No (6): Water for Injections	68
3-4 Preparation of the Samples	68

3-4-1 Prepare Method No (1):	68
3-4-2 Prepare Method No (2).....	69
3-5 Experimental Procedure	70

Chapter Four: Results and Discussion

4-1 Introduction	72
4-2 Results of Dextrose (Sugar)	72
4-2-1 Laser Transmission at (0) angle	72
4-2-2 Laser Scattering at (45) angle	75
4-2-3 Laser Scattering at (90) angle	76
4-2-4 Laser Scattering at (135) angle	79
4-3 Results of Sodium Chloride (NaCl)	82
4-3-1 Laser Transmission at (0) angle	82
4-3-2 Laser Scattering at (45) angle	84
4-3-3 Laser Scattering at (90) angle	85
4-3-4 Laser Scattering at (135) angle	87
4-4 Results of Benzylpenicillin Sodium (BS)	90
4-4-1 Laser Transmission at (0) angle	91
4-4-2 Laser Scattering at (45) angle	92
4-4-3 Laser Scattering at (90) angle	94
4-4-4 Laser Scattering at (135) angle	95
4-5 Results of Metronidazole	98
4-5-1 Laser Transmission at (0) angle	98
4-5-2 Laser Scattering at (45) angle	99
4-5-3 Laser Scattering at (90) angle	101
4-5-4 Laser Scattering at (135) angle	103
4-6 Results of Actrapid HM Insulin Human (IH)	106
4-6-1 Prepare IH by High Dilution	106
4-6-1-1 Laser Transmission at (0) angle	107

4-6-1-2 Laser Scattering at (45) angle	108
4-6-1-3 Laser Scattering at (90) angle	110
4-6-1-4 Laser Scattering at (135) angle	112
4-6-2 Prepare IH by Low Dilution	114
4-6-2-1 Laser Transmission at (0) angle	114
4-6-2-2 Laser Scattering at (45) angle	116
4-6-2-3 Laser Scattering at (90) angle	117
4-6-2-4 Laser Scattering at (135) angle	119
4-7 The Discussion	121
4-8 Conclusions	123
4-9 Future Work	124
References	125