Indian Institute of Teacher Education

3.1.2 The institution provides seed money to its teachers for research

Index Page:

Indian Institute of Teacher Education (IITE)

A State University established by Govt. of Gujarat

Centre of Research

MINOR RESEARCH PROJECT COMPLETION CERTIFICATE

WHOM SO EVER IT MAY BE CONCERNED

This is to certify that Dr. Tejas Pavagadhi, Assistant Professor, Department of Chemistry, (IITE) as Principal Investigator and Dr. Sachin Undre, Assistant Professor, Department of Chemistry, IITE as Co-investigator have carried out Minor Research Project sponsored by Indian Institute of Teacher Education (IITE), Gandhinagar. The investigators worked on the research project entitled **"Biocompatible polymers for binding and releasing capacities of anticancer drugs studied by using Survismeter"** in the subject of Chemistry and submitted the report successfully. The evaluation committee approved the project report.

B. S. Patel

Director
Centre of Research
IITE

Date: 10-03-2018
Place: Gandhinagar

Copy to:

1. Dr. Tejas Pavagadhi, Asst. Prof., Dept of Chemistry
2. Dr. Sachin Undre, Asst. Prof., Dept of Chemistry
3. Office file

Indian Institute Teacher Education, Gandhinagar
Ramkrushna Paramhans Vidya Sankul,
Near KH-5, KH- Road, Sector-15
Gandhinagar, Gujarat -382016
Website: www.iite.ac.in

Date: 14/07/2017

To,
Centre of Research
Indian Institute of Teacher Education
Gandhinagar

Subject: Final report of Minor Research Project.

F. No.: Ref. No. IITE/920/2016

Dear Sir,

Centre of Research has sanctioned a Minor Research Project entitled as **"Biocompatible polymers for binding and releasing capacities of anticancer drugs studied by using Survismeter"** [vide letter **No. IITE/920/2016** dated 25th Nov 2016]. The project has been completed and proposed objectives have been achieved.

We are submitting the final report of the minor research project. The research paper will be published out of the research work conducted in this project.

The details of the final report are enclosed herewith.

Thanking you.

Yours Sincerely,

Dr. Tejas H. Pavagadhi
Principal Investigator
HOD, Department of Chemistry
IITE, Gandhinagar

Dr. Sachin Bhagwatrao Undre
Co-Investigator
Assistant Professor, Department of Chemistry
IITE, Gandhinagar

Forwarded Through

Dean & Principal, IITE

Sheet A

Summary of the findings of the study

The multifunctional materials of multipurpose uses with several polymeric linear branchings having innumeral binding sites are in high demands for their drug binding, loading potential and biocoatings are increasingly attracting attention today. The biocompatible Polyethylene Glycol (PEG) polymer, was used for binding and releasing activity for silibinin (SB) anticancer drug. The larger linear chain and attached –OH groups of this PEG polymer implied that the PEG could be used as prospective drug binders. The linear chain along with functional group had enhanced binding activity to trap the drugs and toxic heavy metals for their distribution and bioremediation, respectively. Thus, the SB-PEG (Drug-Polymer) complex in a 1:1 ratio with Dichloromethane (DCM), was prepared. Further, The SB-PEG complex were characterized with X-ray powder diffraction (XRD), Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier transform infrared (FTIR) Spectroscopy, Scanning Electron Microscopy (SEM), Dynamic light scattering (DLS) and their physicochemical profile was studied with Borosil Mansingh Survismeter. These results inferred the complex formation between SB and PEG.

The capacity and activities of PEG for encapsulate or conjugate a maximum amount of SB as an anticancer drug and there in vitro releasing activity was investigated.

The physicochemical properties of PEG, SB and released SB (from PEG) show that the intermolecular interactions between the end group and the in phosphate buffered saline with 10% dimethyl sulfoxide molecule play an important role for determining binding activities. The variation in their physicochemical characterization have inferred the contribution of each functional groups in SB and PEG. A variation in physicochemical properties have been noted and proven the impact of functional groups of SB and PEG with enhancing the structural activities.

These structural activities could be an asset for developing the application for drug binding and loading with controlled release and applicable in field of biomedical and biochemical process. The PEG having linear branching mechanically referred to as biding sites assisted the trapping of the targeted drug for making sure that the impacts of drug on disease are successful. The presence of -OH at the end linear chains with PEG assists them in conjugating SB drug molecule, which is greatly useful in drug delivery systems. The higher binding capacities of PEG for the conjugation of silibinin were retrieved by XRD, NMR, FTIR, SEM, DLS and their physicochemical profile for targeting and sustainable intracellular drug delivery capabilities.

The capacity and activities of the PEG to bind a maximum amount of SB as an anticancer drug and their in vitro releasing activity was investigated. The SB anticancer drug released from PEG was studied using Borosil Mansingh Survismeter by determining physicochemical properties (PCPs). The PCPs such as density (ρ, $\pm 10^{-3}$ kg m^{-3}), viscosity (η, $\pm 10^{-4}$ mPa.s), surface tension (γ $\pm$ 0.01 mNm^{-1}), friccohesity (σ, $\pm$ $s.m^{-1}$ 10^{-5}), activation energy ($\Delta\mu_2^* \pm 10^{-2}$kJ/mol) and molecular redii (r $\pm$ 0.01nm) of PEG-SB and released SB from PEG in appropriate solvents were determined for binding and releasing activity. Also, the release kinetic of SB from PEG confirmed with ultraviolet–visible spectroscopy (UV-Vis) at a 330-nm λmax showed about 9%/h SB released in phosphate buffered saline with 10% dimethyl sulfoxide (PD).

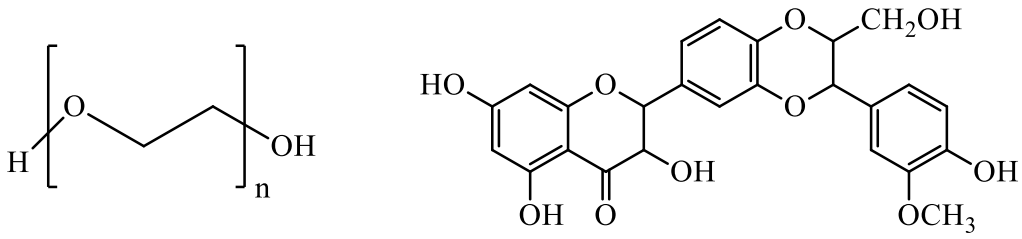
The release capacity of PEG was found to be higher with sustained release. Due to this behavior; the SB-PEG (complex) was investigated for in vitro SB anticancer study and evaluated by the Sulforhodamine B colorimetric (SRB) assay on Human Breast Cancer Cell Line MCF-7 with varying concentrations (10, 20, 40 and 80 μg/mL) of each these agents. These SRB assay results showed that the SB-PEG useful in cancer cell death at the characteristic concentrations of 80 μg/mL. This study clearly elucidates the improved significant anticancer response of PEG upon

SB binding. An interesting aspect of the carried out investigation showed that SB could mediate the anticancer effect even at lower concentrations with 50% control growth inhibition of MCF-7 human breast cancer cell when it is bind with PEG polymer.

These initial results are auspicious and assist as a foundation for the research and developing applications described in this report. Thereby, our work is considered to be very much of industrial and pharmaceutical significance, and also in adsorption material technology.

All results obtained by proposed research work have confirmed the successful binding of SB with PEG and their releasing activities. The obtained results such as XRD, NMR, FTIR, SEM, DLS and their physicochemical properties are given below.

1. **Chemical Structures of Polyethylene glycol (PEG) and Silibinin (SB)**



(a) (b)

Figure 1.1 Chemical structure of (a) Polyethylene glycol (PEG) and (b) Silibinin (SB)

2. Characterization of SB-PEG complexes

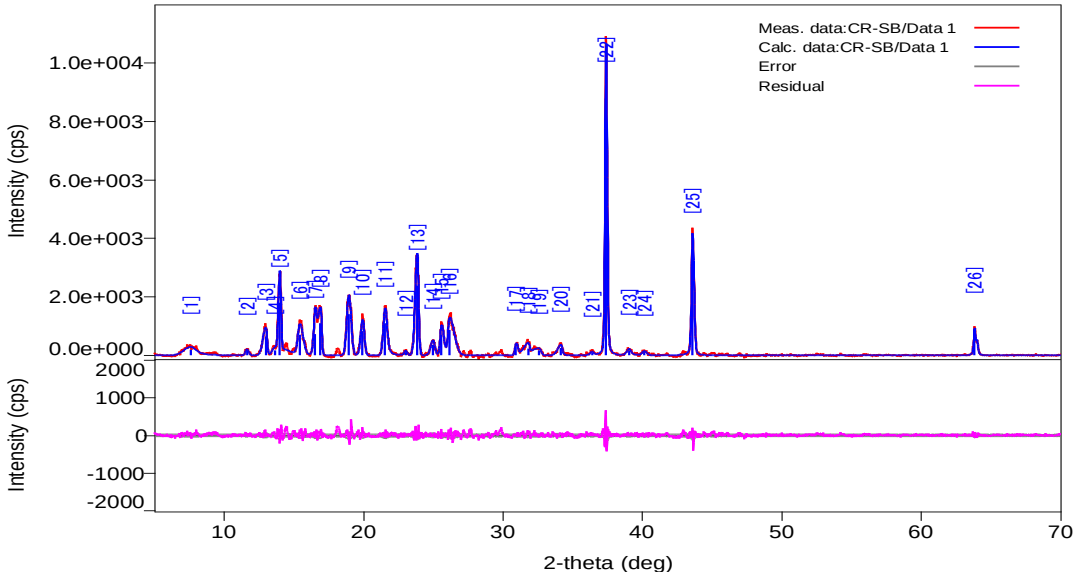


Figure. 2 a) XRD spectrum of SB

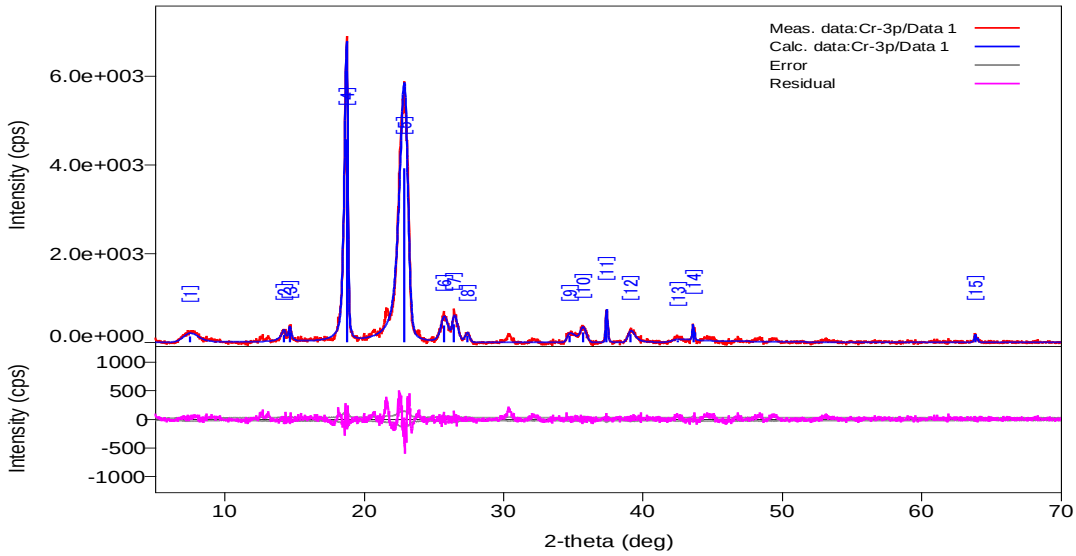


Figure. 2 b) XRD spectrum of PEG

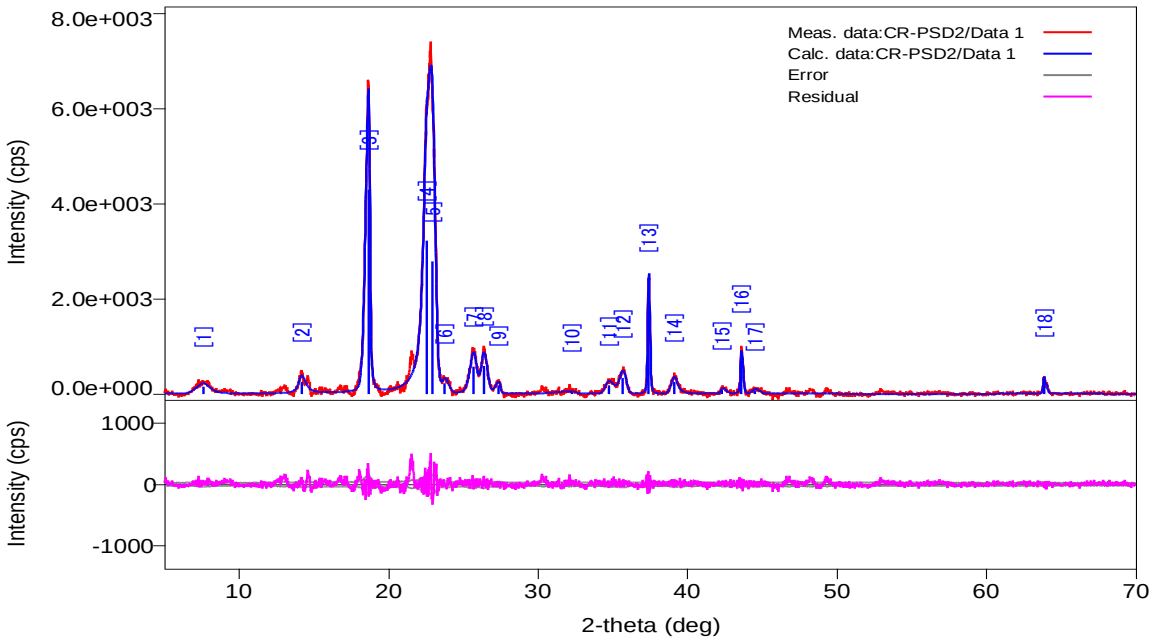


Figure. 2 c) XRD spectrum of SB-PEG complex

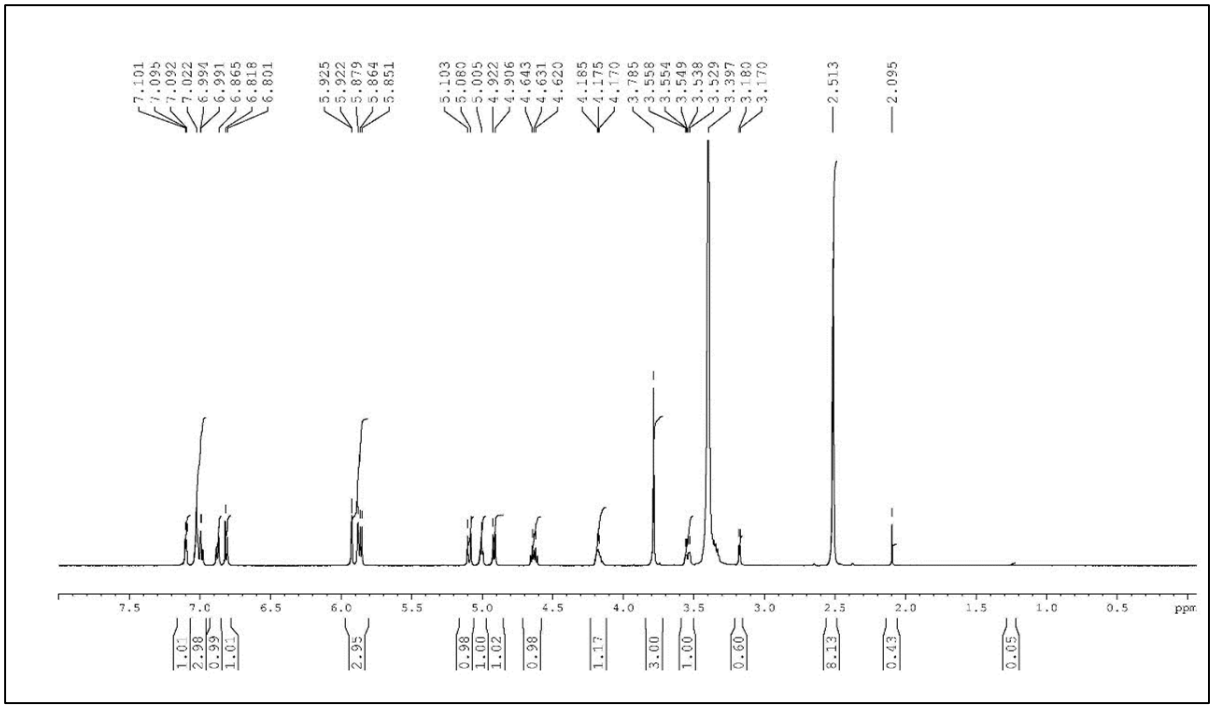


Figure. 3 a) H^1 NMR spectra of SB

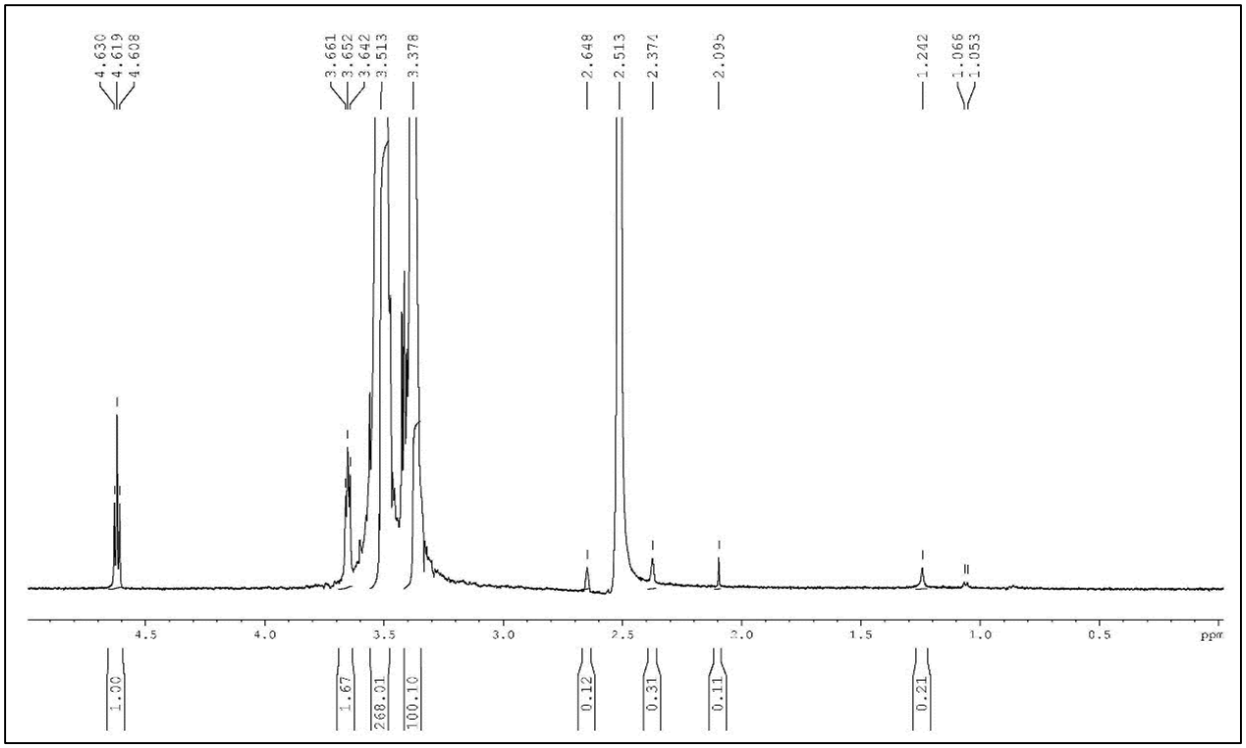


Figure. 3 b) H^1 NMR spectrum of PEG

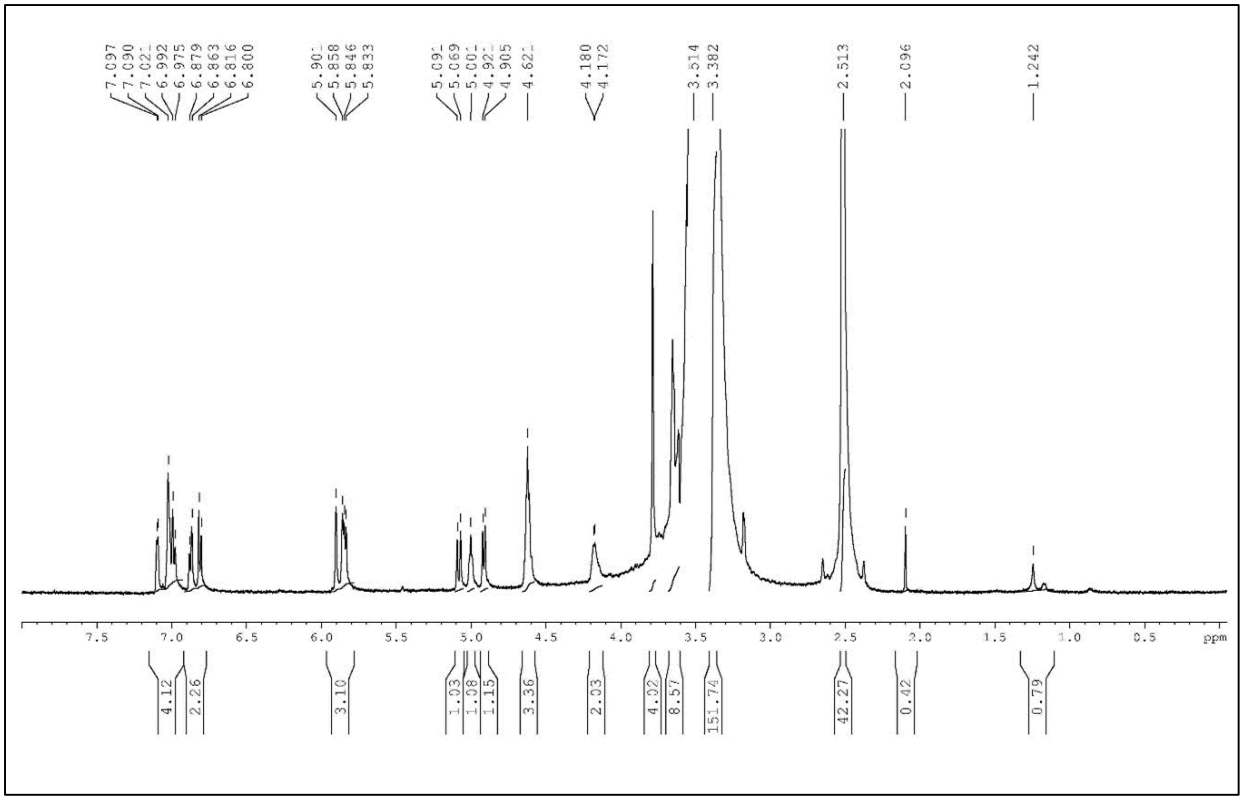


Figure. 3 c) H^1 NMR spectrum of SB-PEG

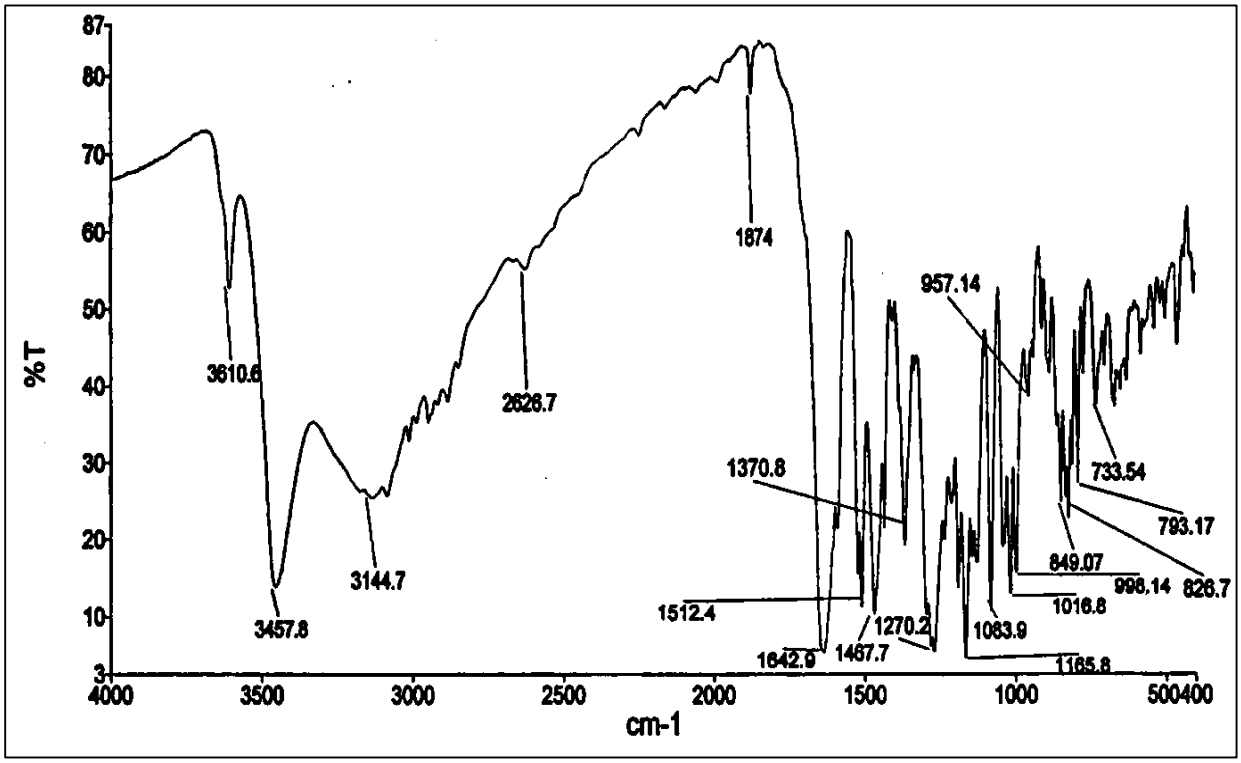


Figure. 4 a) FTIR of SB

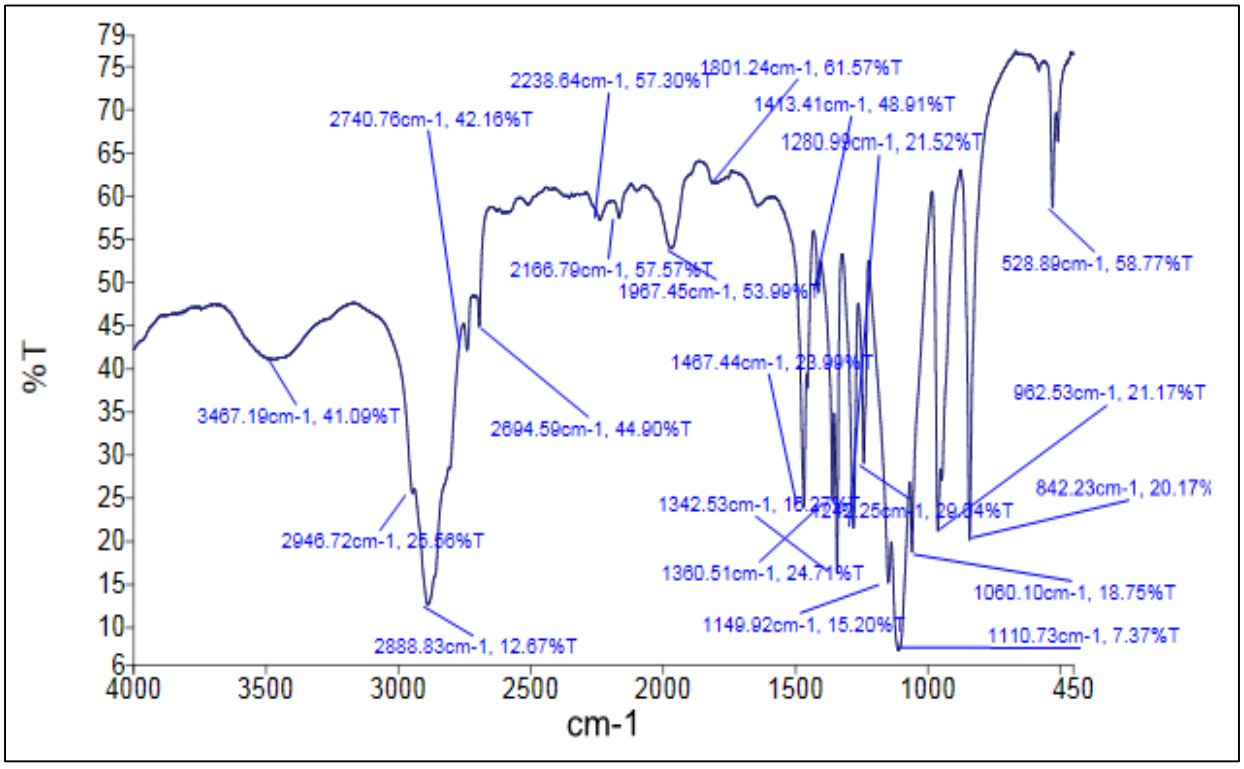


Figure. 4 b) FTIR of PEG

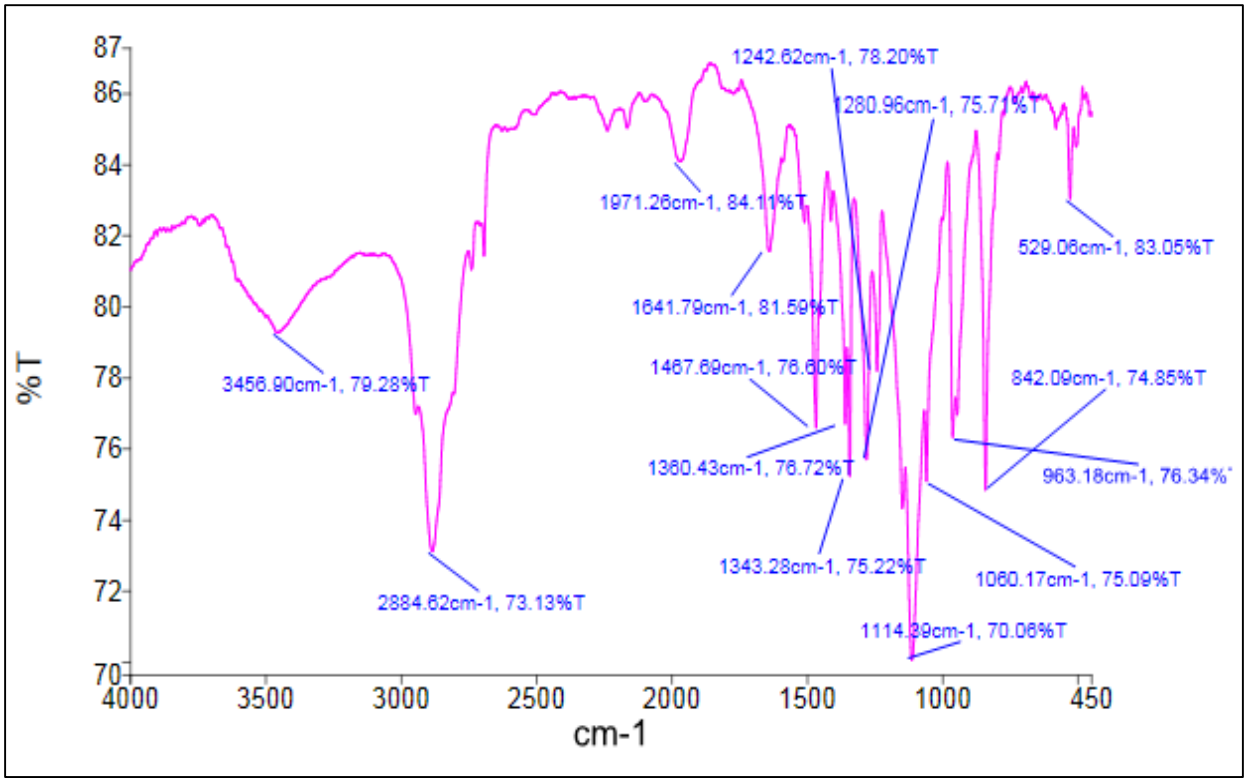


Figure. 4 c) FTIR of SB-PEG

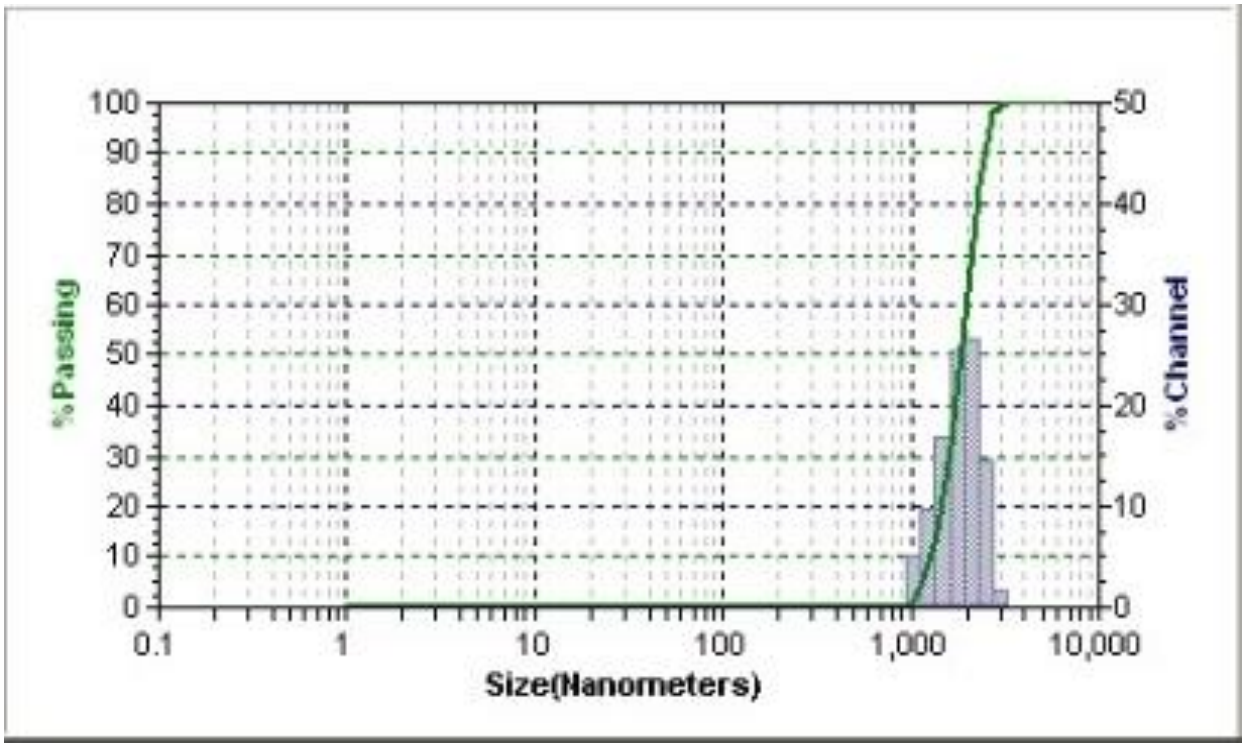


Figure. 5 a) Size distribution of SB

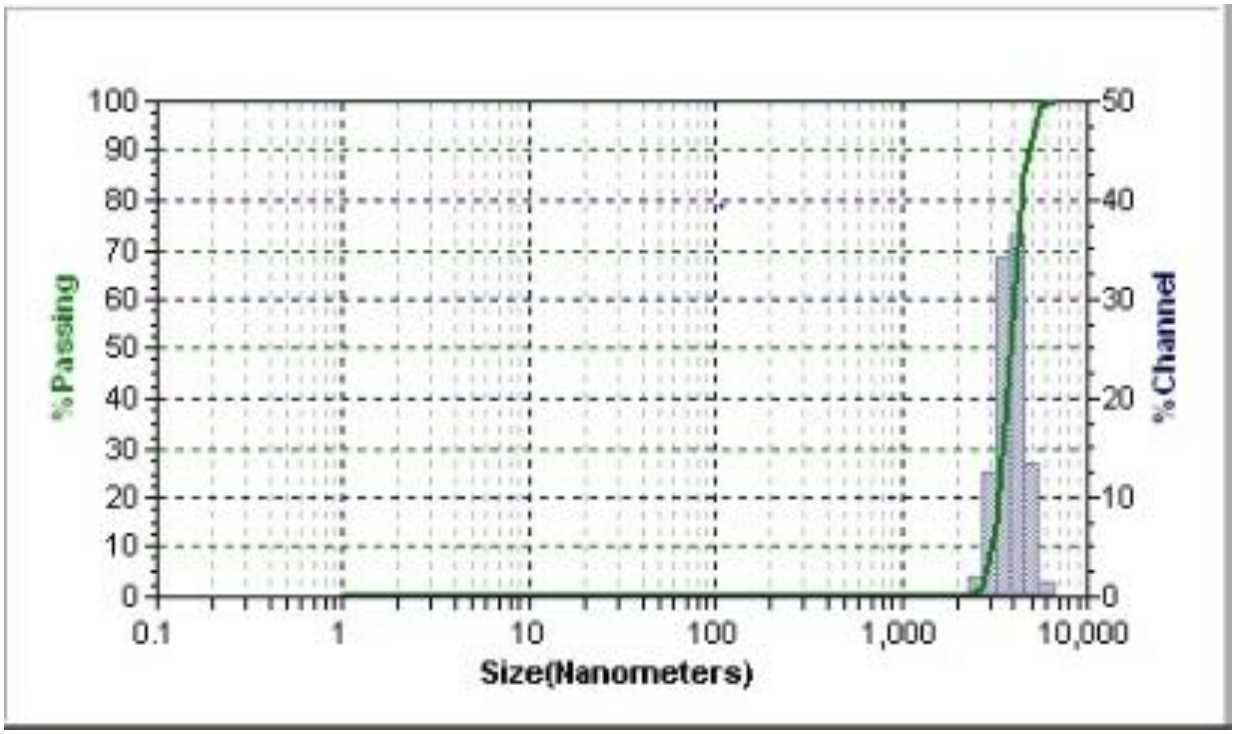


Figure. 5 b) Size distribution of PEG

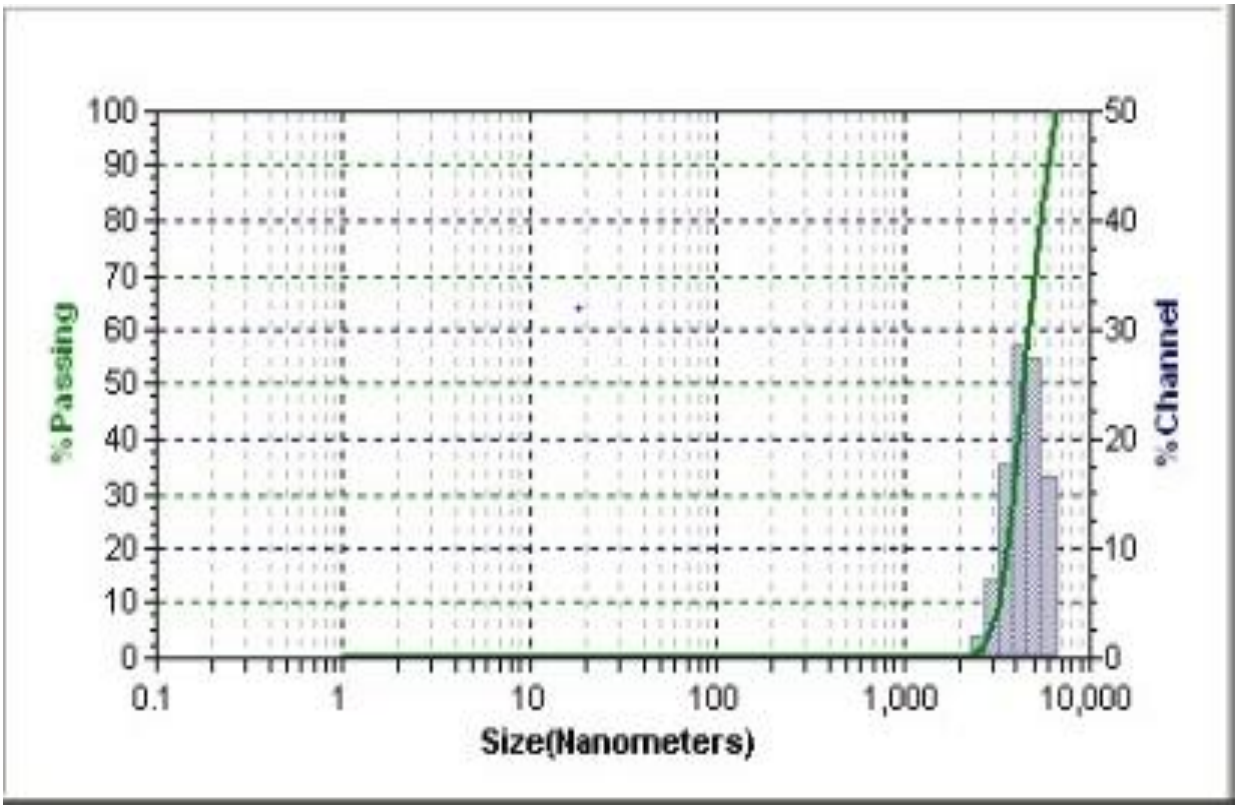


Figure. 5 c) Size distribution of SB-PEG

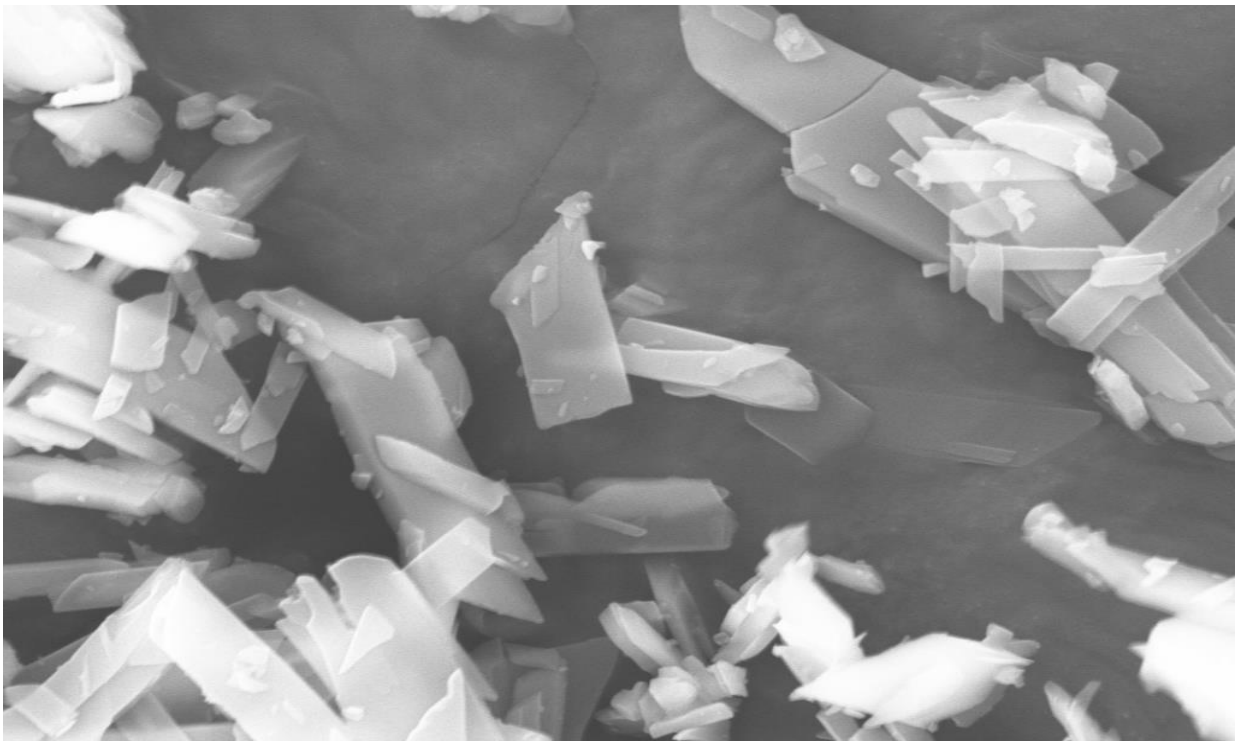


Figure. 6 a) SEM image of SB

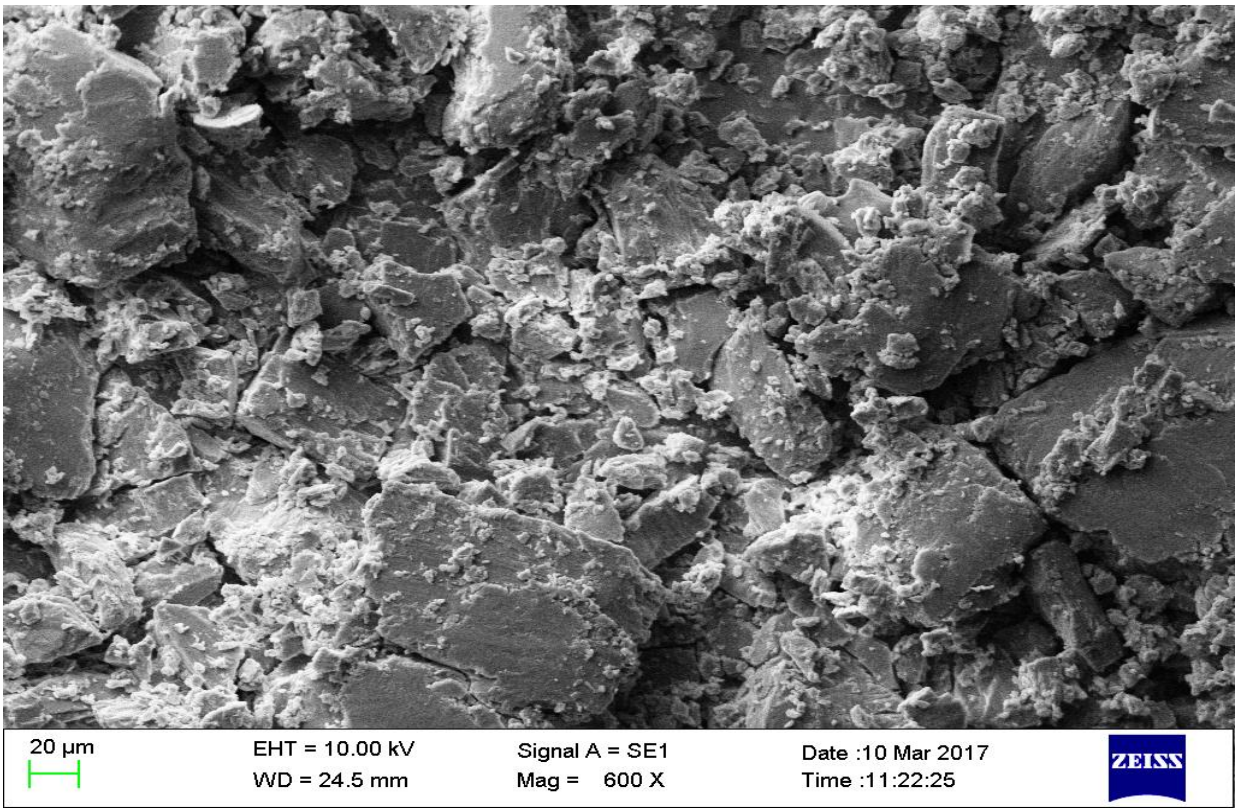


Figure. 6 b) SEM image of PEG

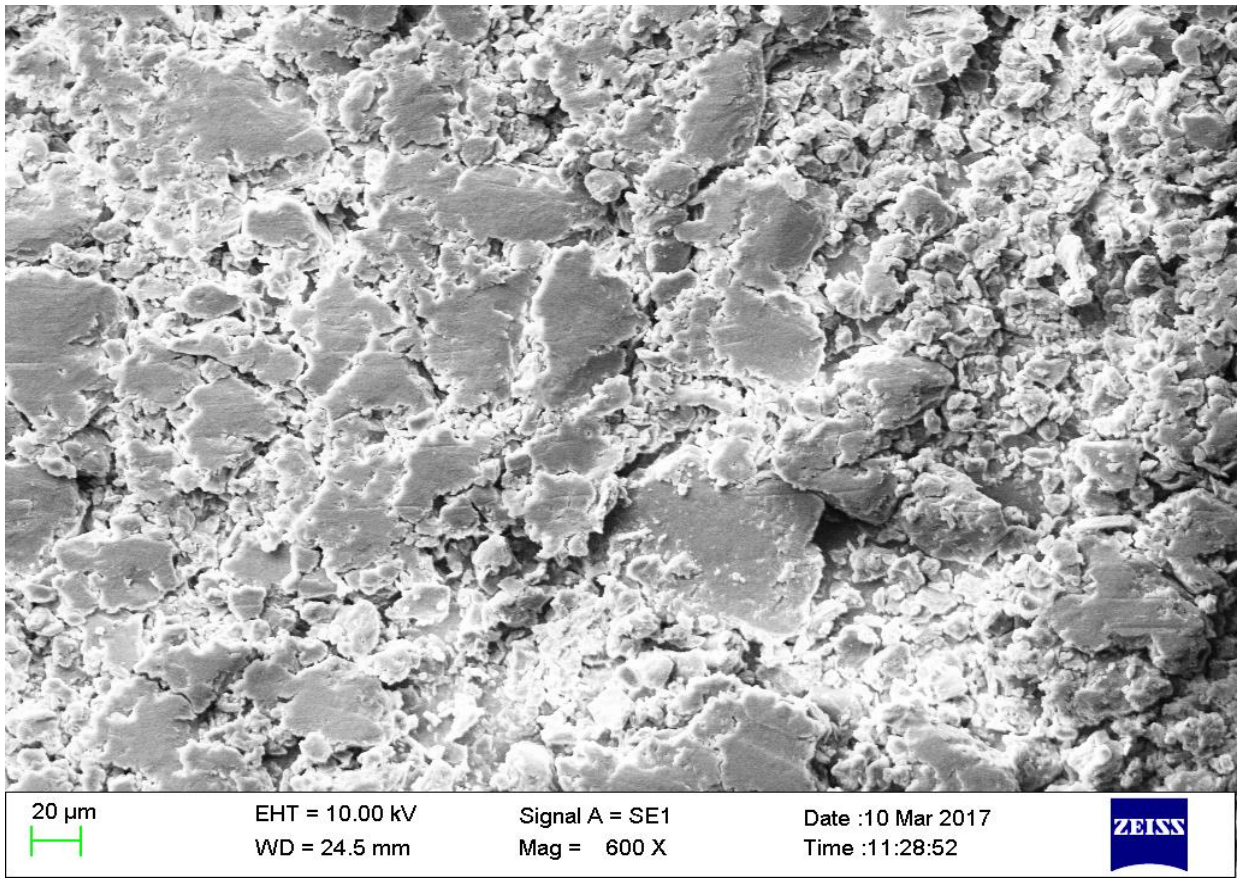


Figure. 6 c) SEM image of SB-PEG

3. Physicochemical properties of SB and PEG in PD medium

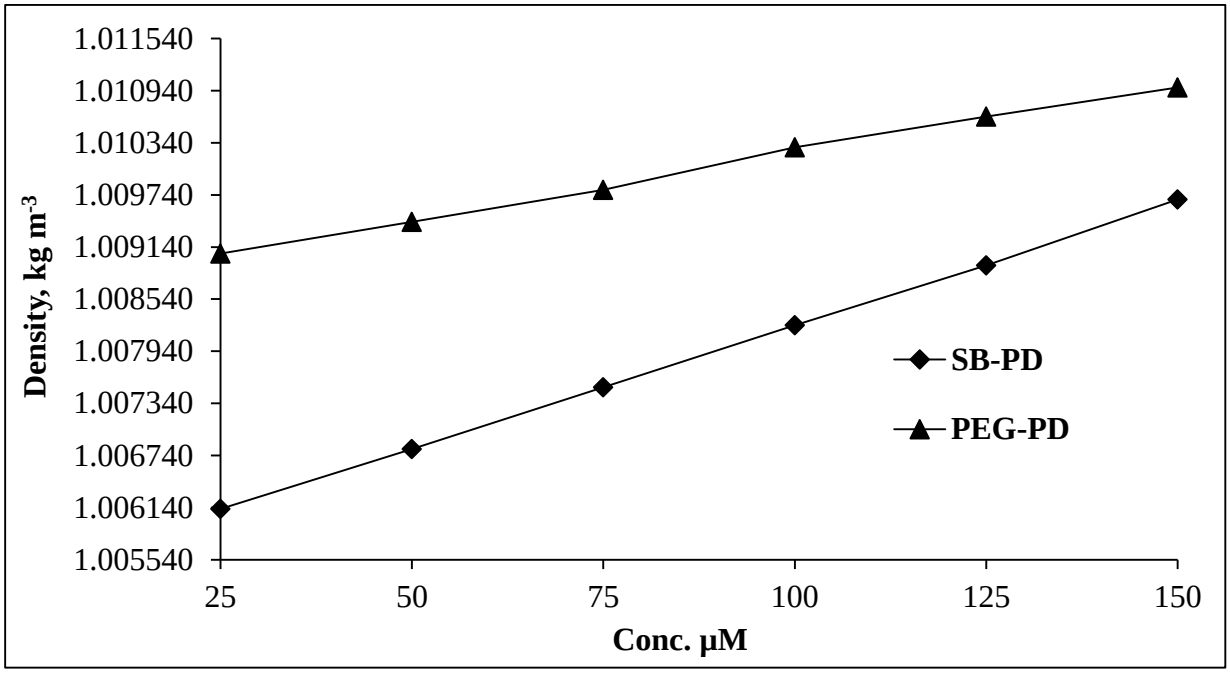


Figure. 7a) Density of SB-PD and PEG-PD

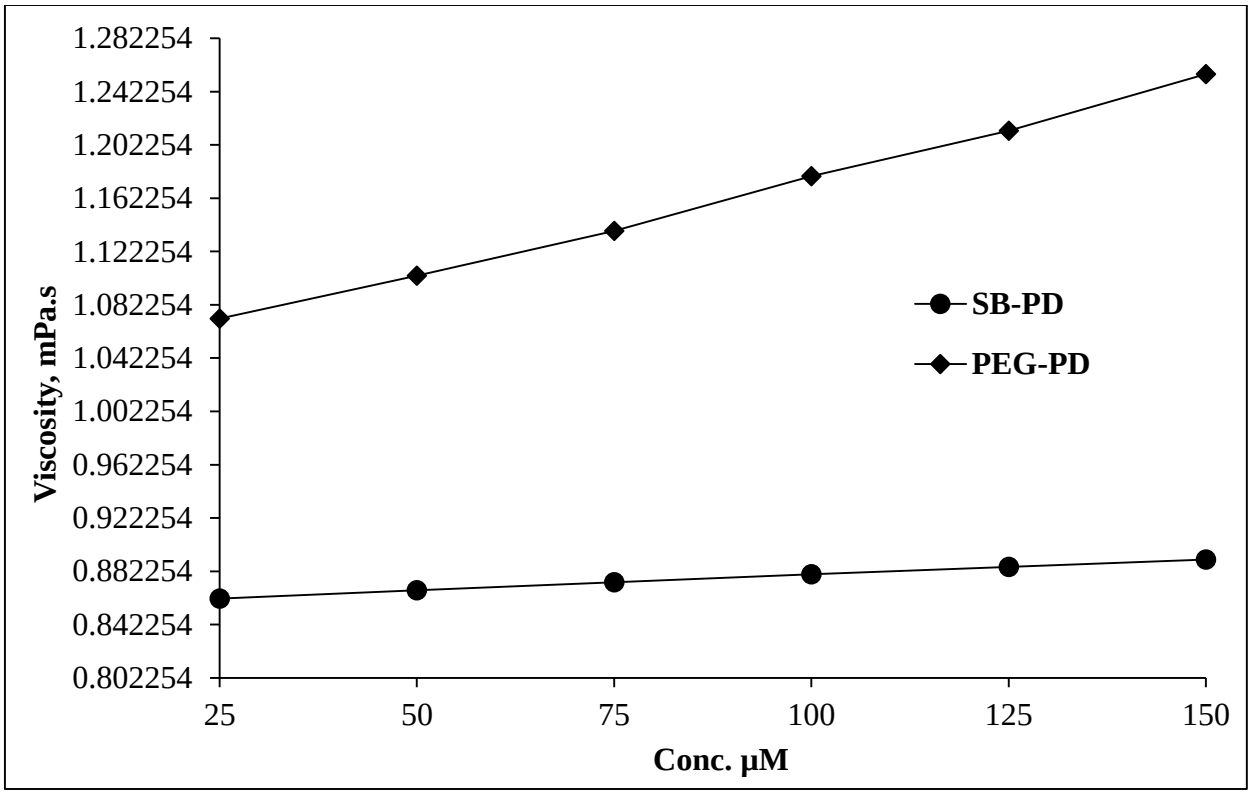


Figure. 7b) Viscosity of SB-PD and PEG-PD

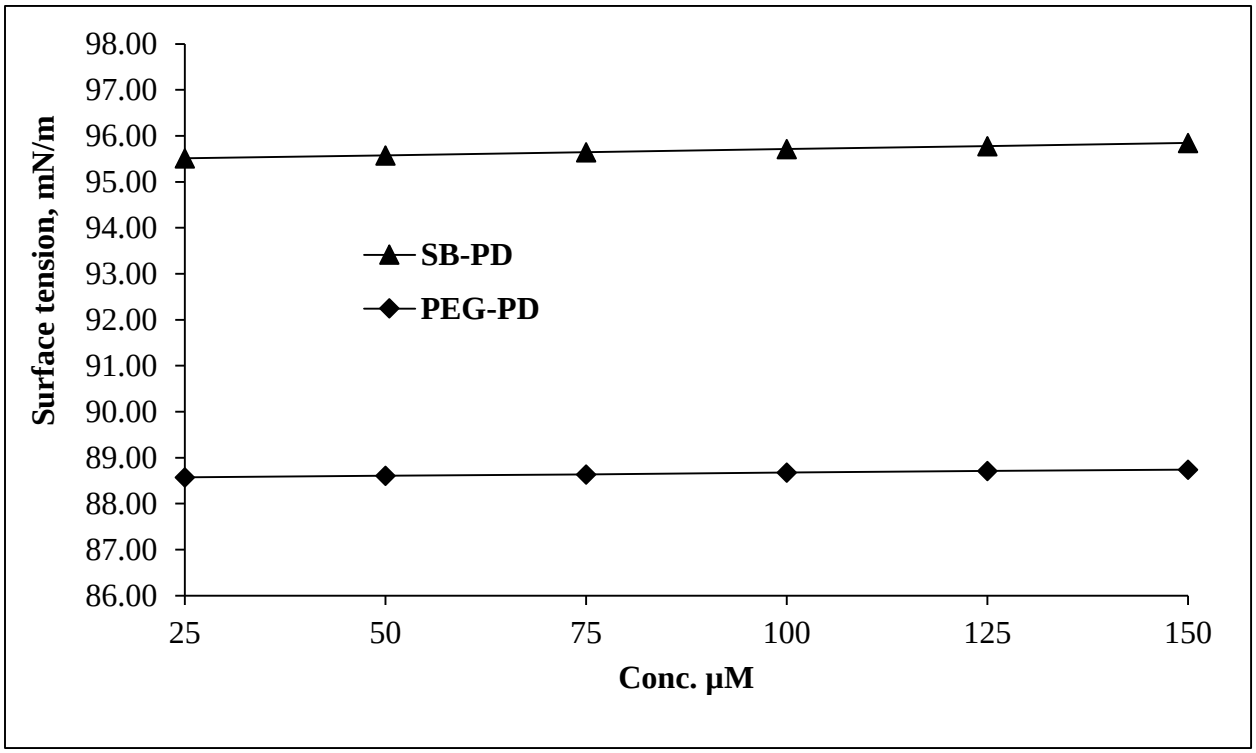


Figure. 7c) Surface tension of SB-PD and PEG-PD

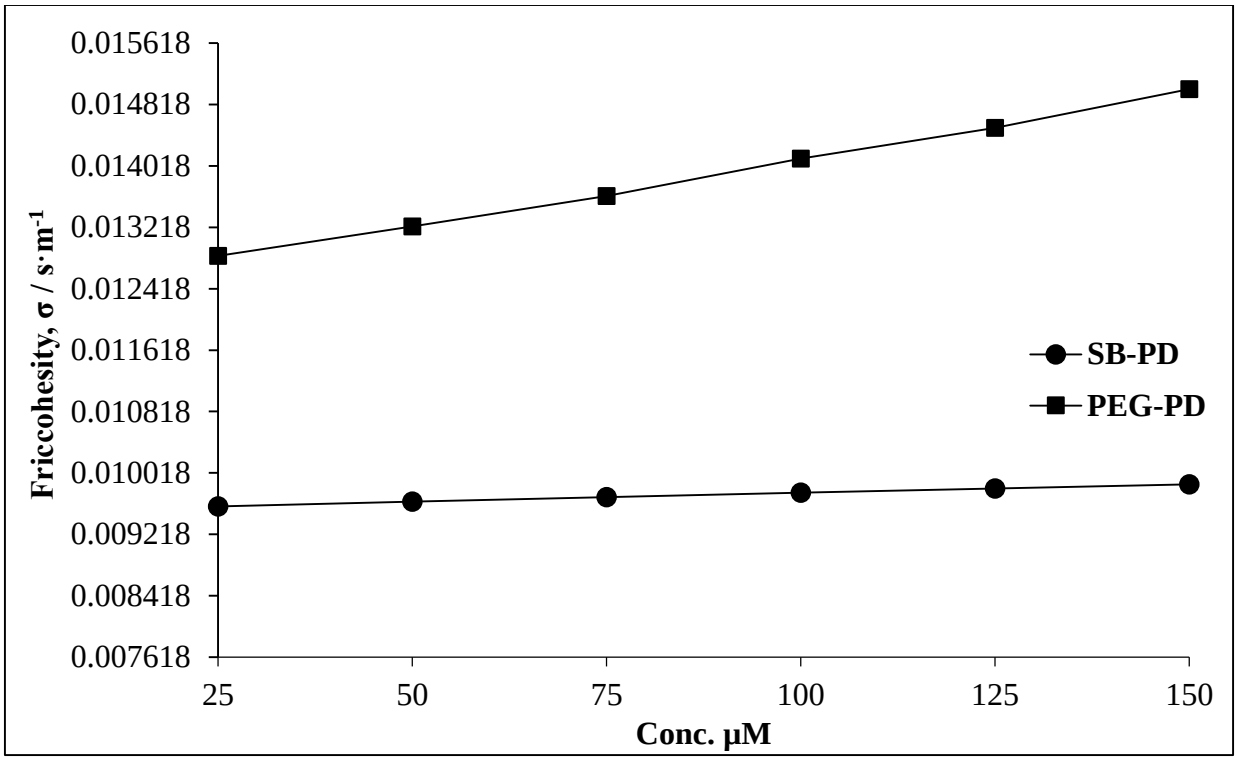


Figure. 7d) Friccohesity of SB-PD and PEG-PD

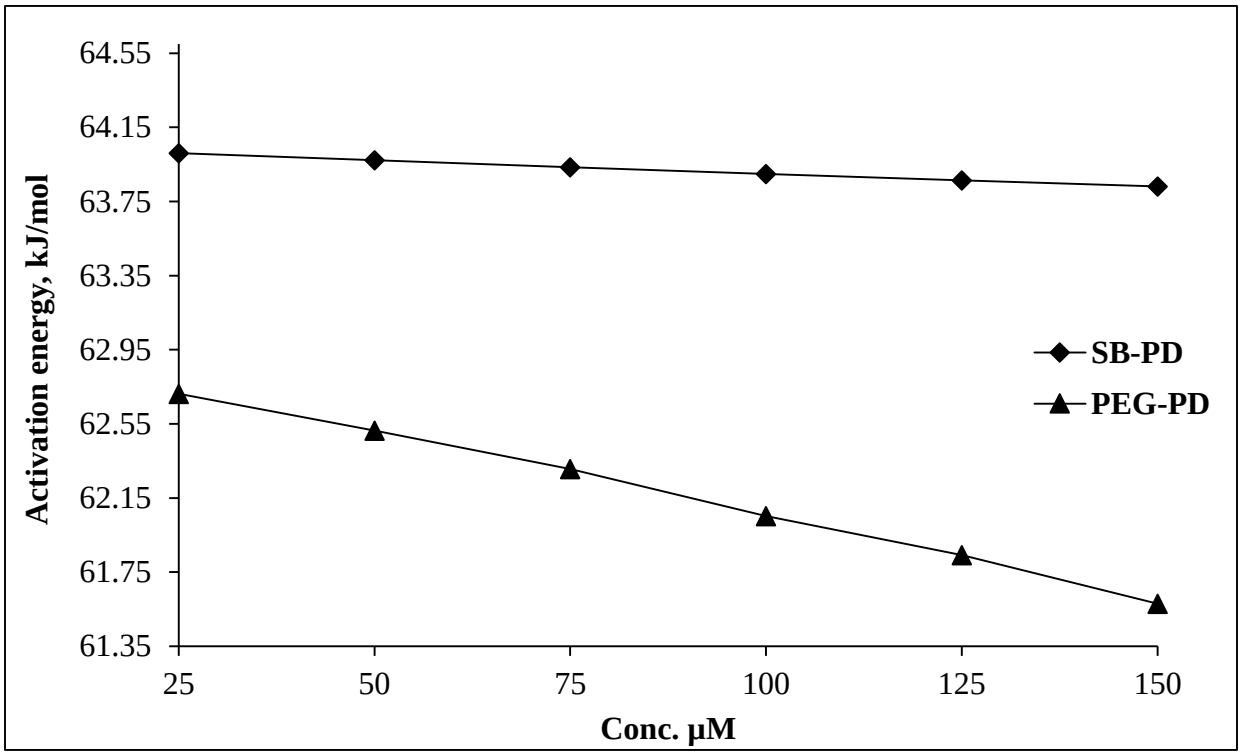


Figure. 7e) Activation energy of SB-PD and PEG-PD

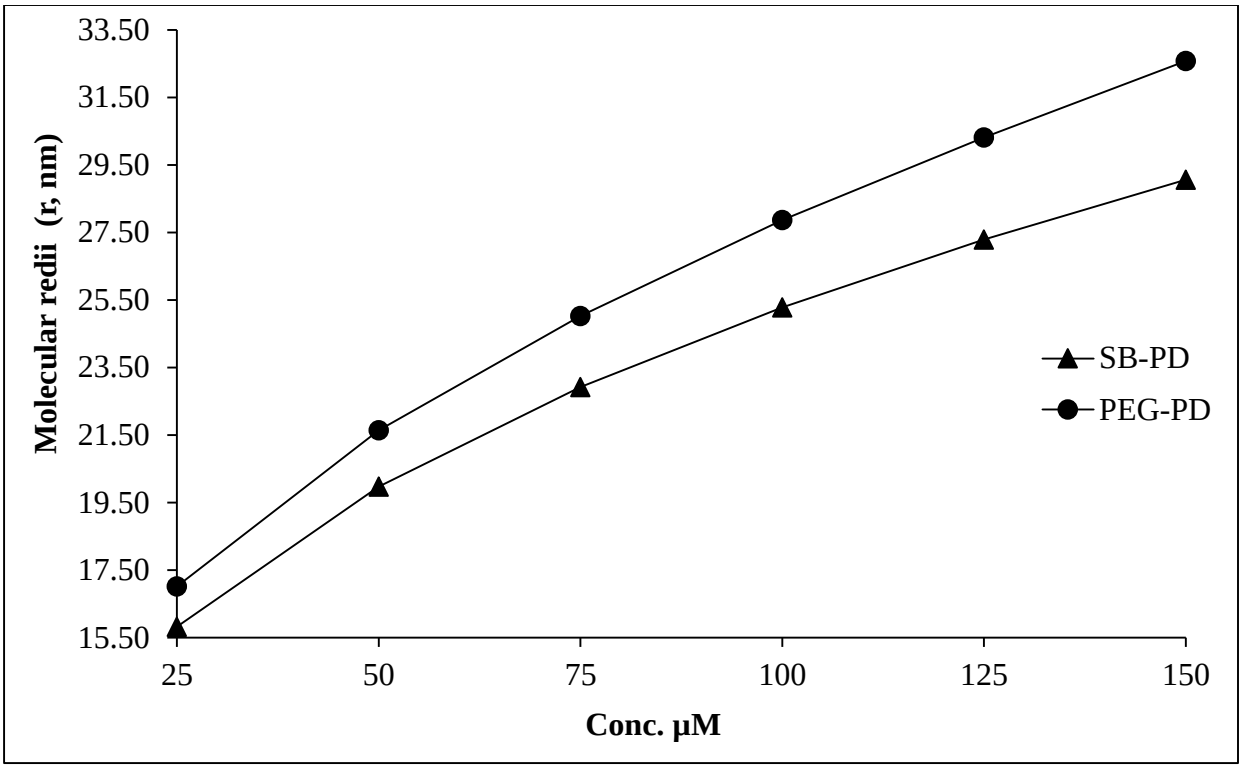


Figure. 7f) Molecular redii of SB-PD and PEG-PD

4. Physicochemical properties of released SB from PEG in PD medium at 37 °C

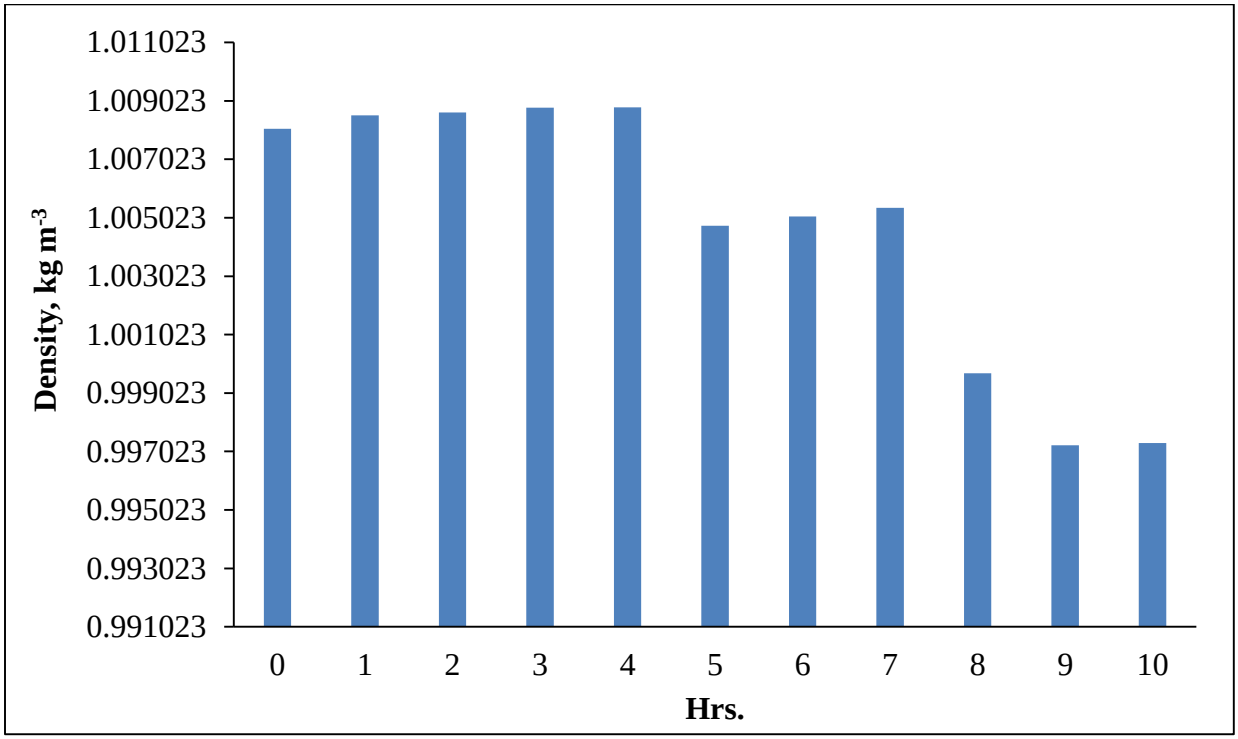


Figure. 8 a) Density of Released SB from PEG in PD medium

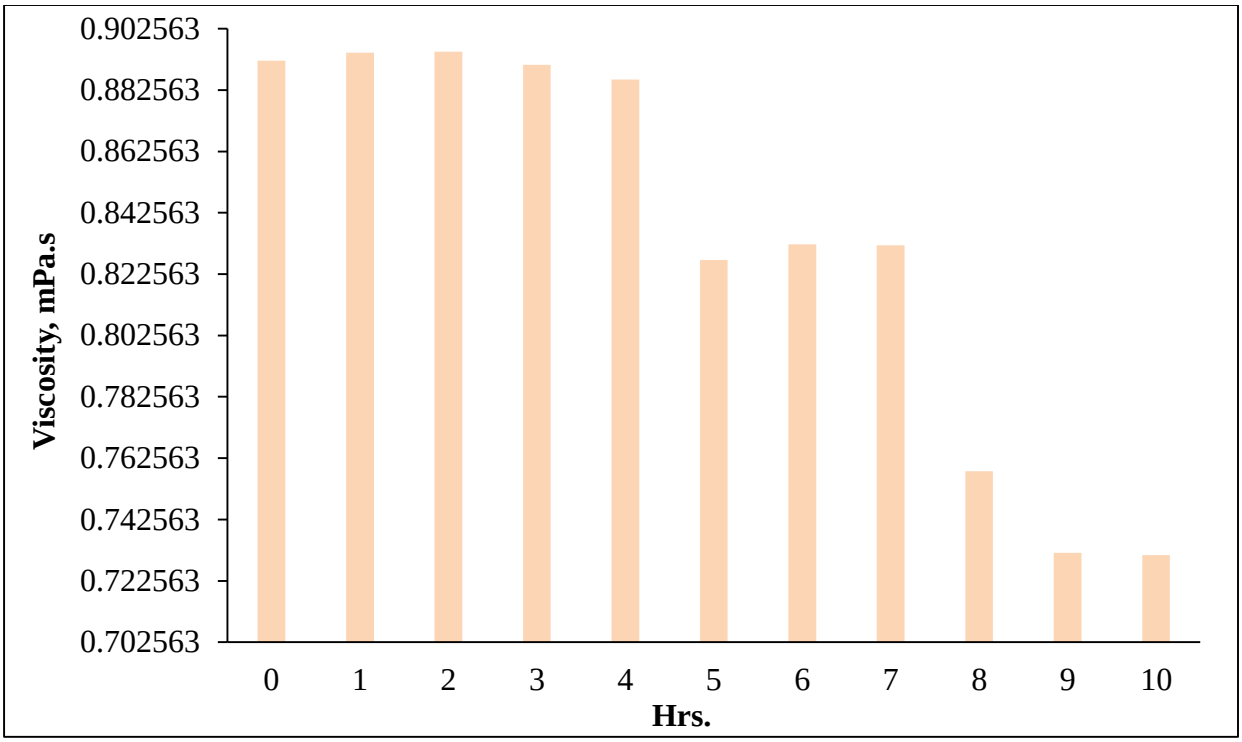


Figure. 8 b) Viscosity of Released SB from PEG in PD medium

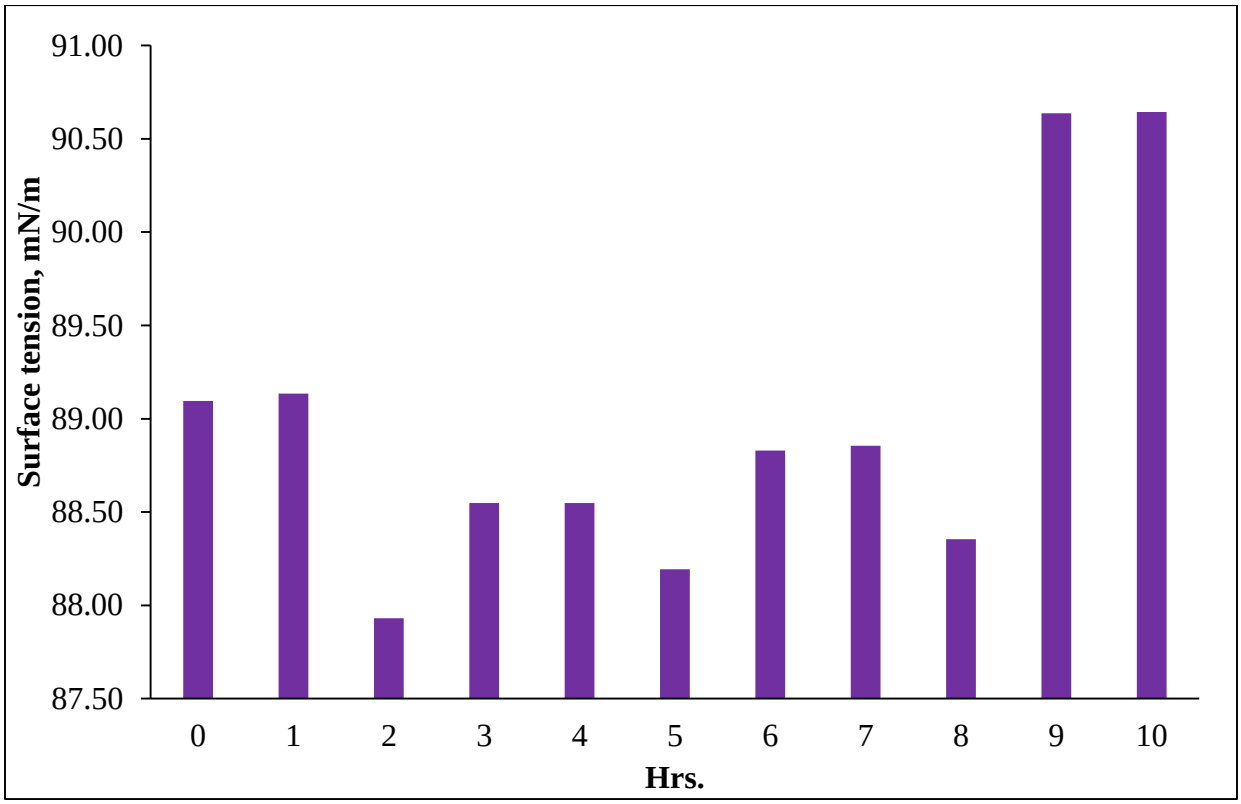


Figure. 8 c) Surface tension of Released SB from PEG in PD medium

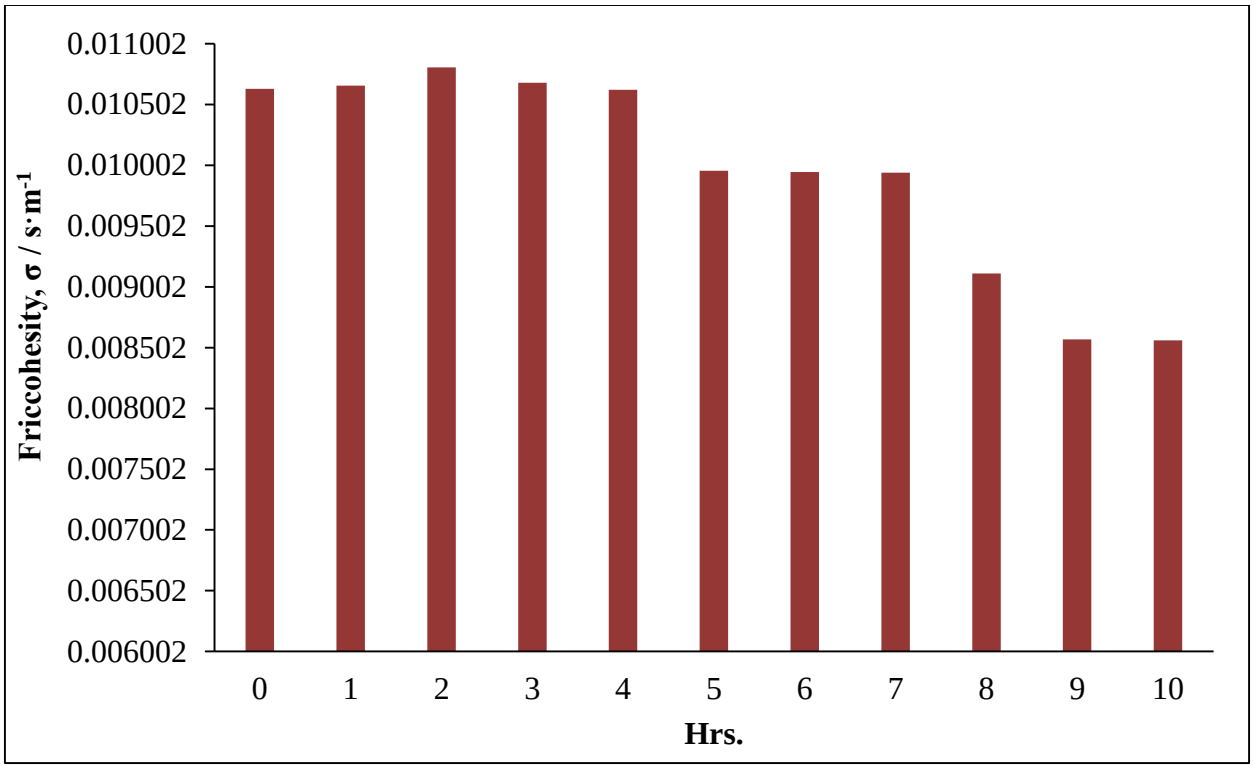


Figure. 8 d) Density of Released SB from PEG in PD medium

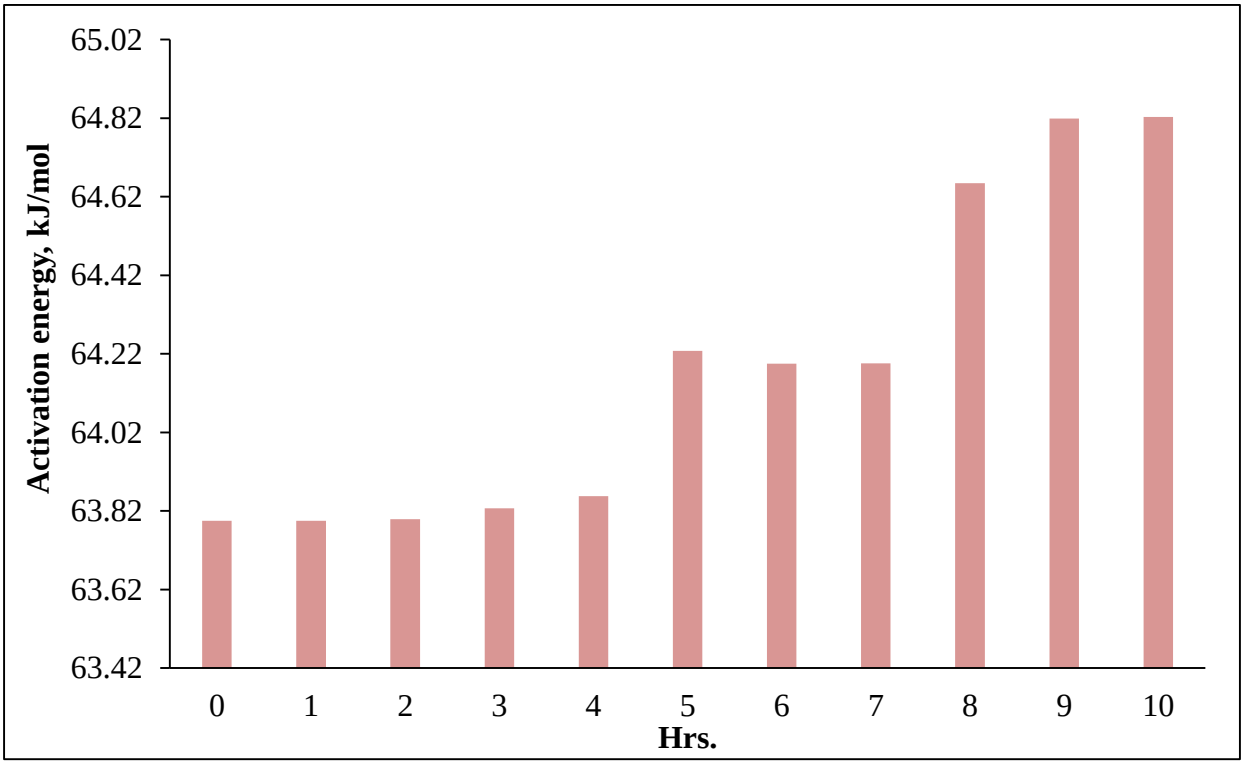


Figure. 8 e) Activation energy of Released SB from PEG in PD medium

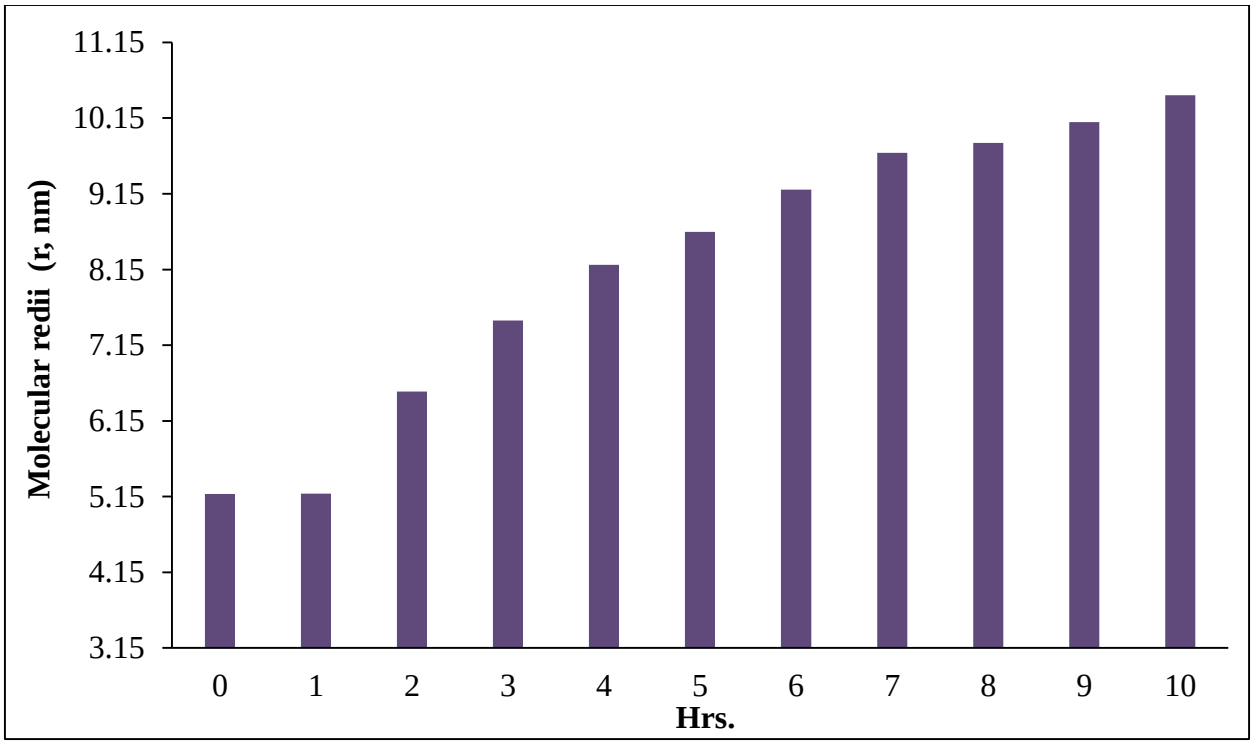


Figure. 8 f) Molecular redii of Released SB from PEG in PD medium

5. UV-Vis analysis of SB and released SB from PEG in PD medium at 37 °C.

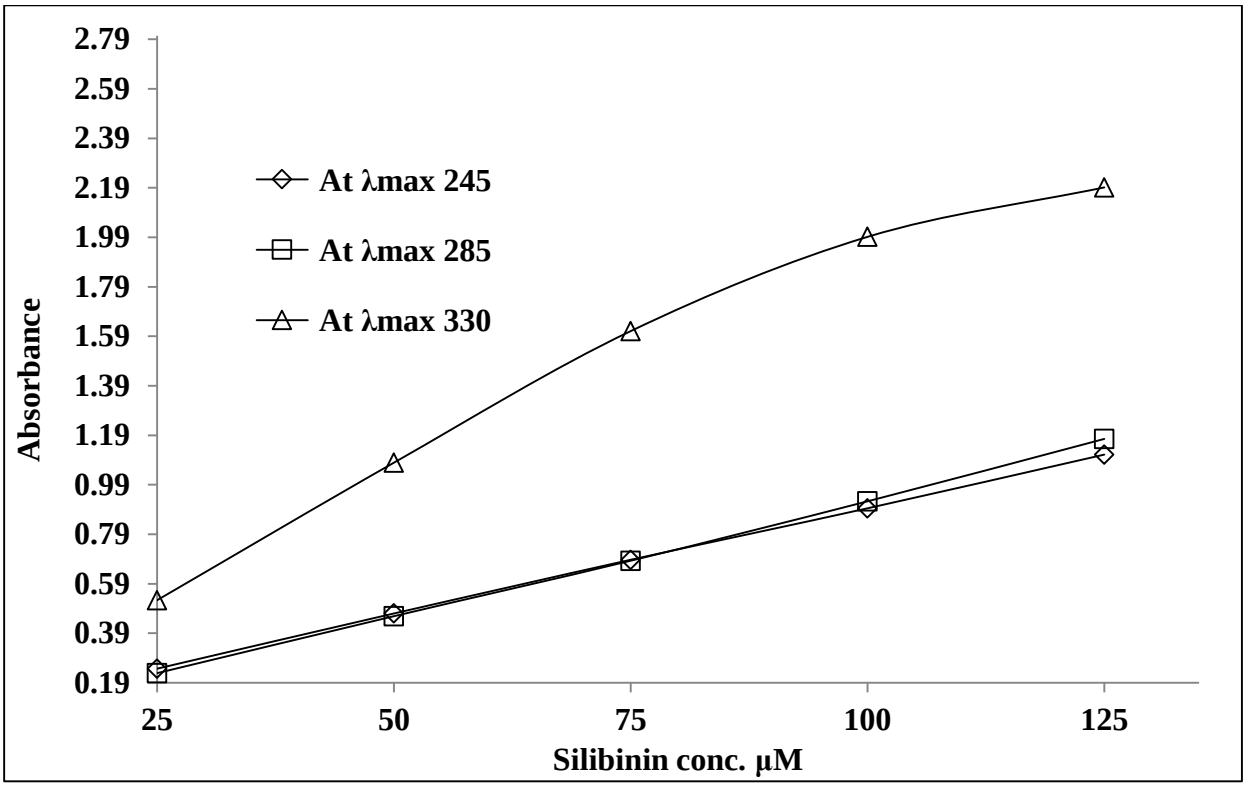


Figure. 9 a) Standard absorbance calibration curve of SB at λ_{max} of 245, 285, 330 nm

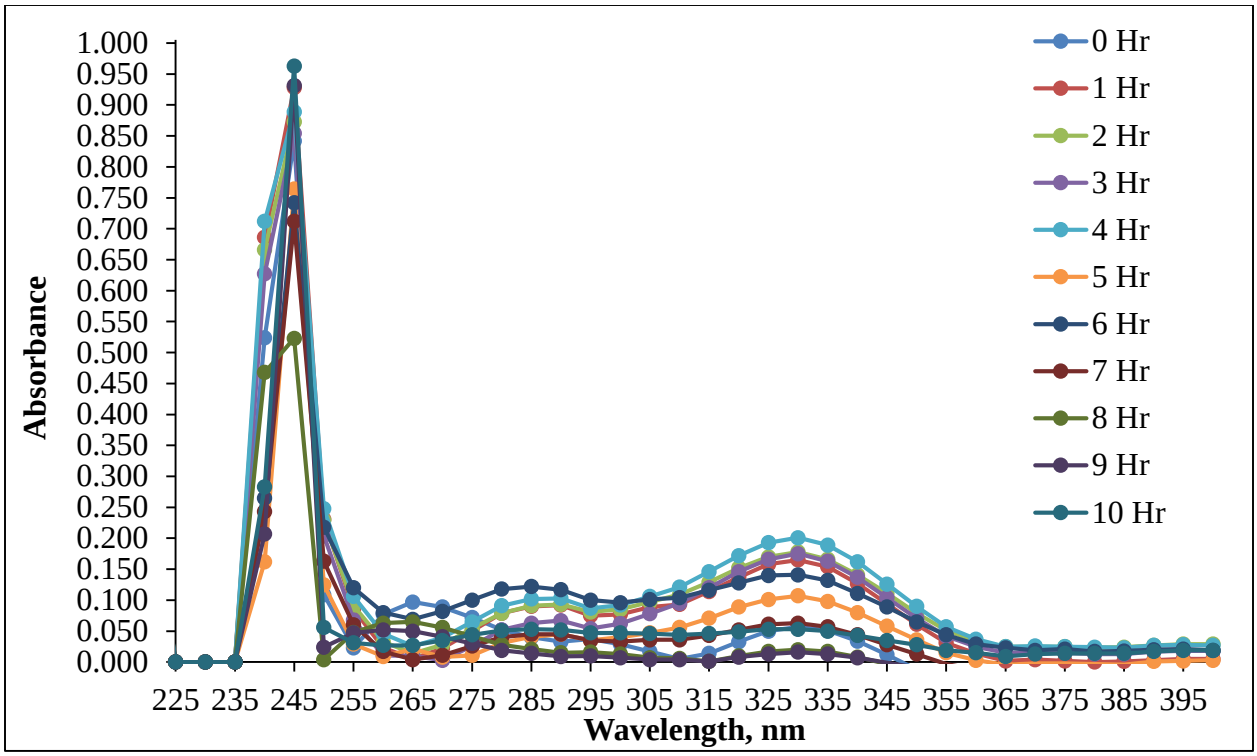


Figure. 9 b) UV-Vis spectra of Released SB from PEG in PD medium

6. Anticancer activity on Human Breast Cancer MCF-7 Cell Line

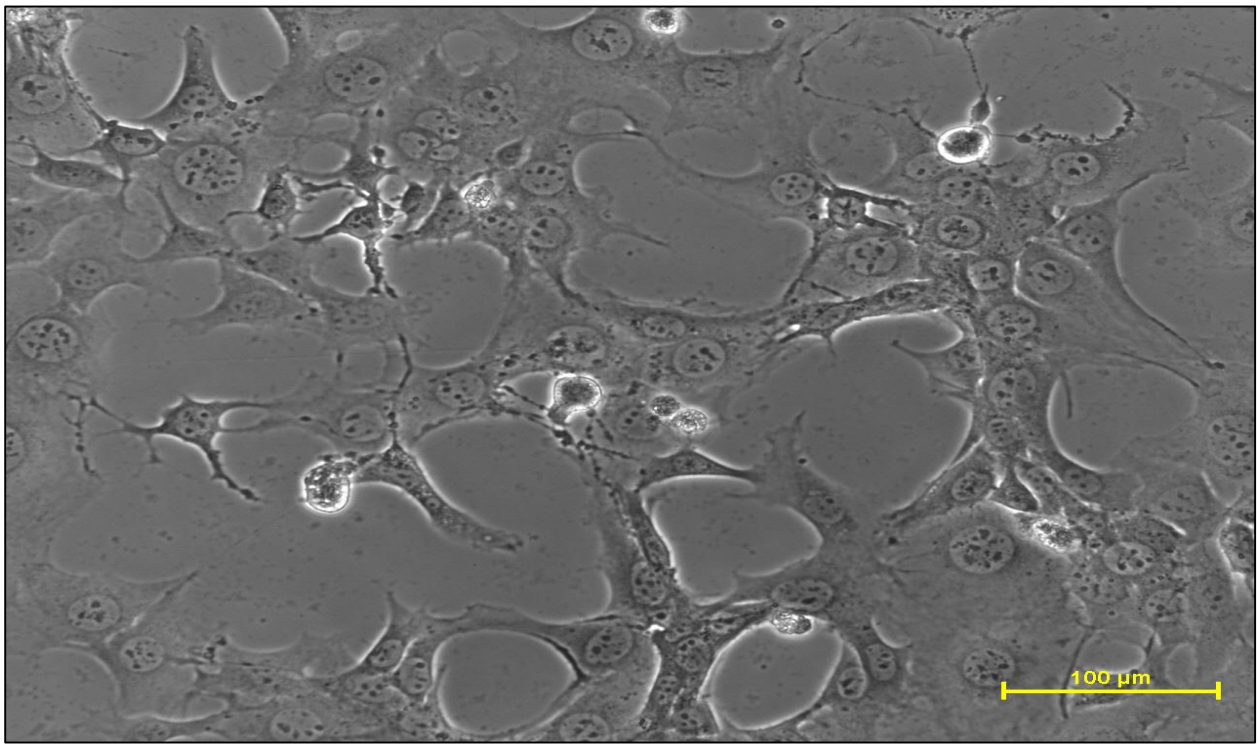


Figure. 10 (a) Image of Human Breast Cancer Cell Line MCF-7 (% Control Growth) treated with 10, 20, 40 and 80 µg/mL concentration of PEG.

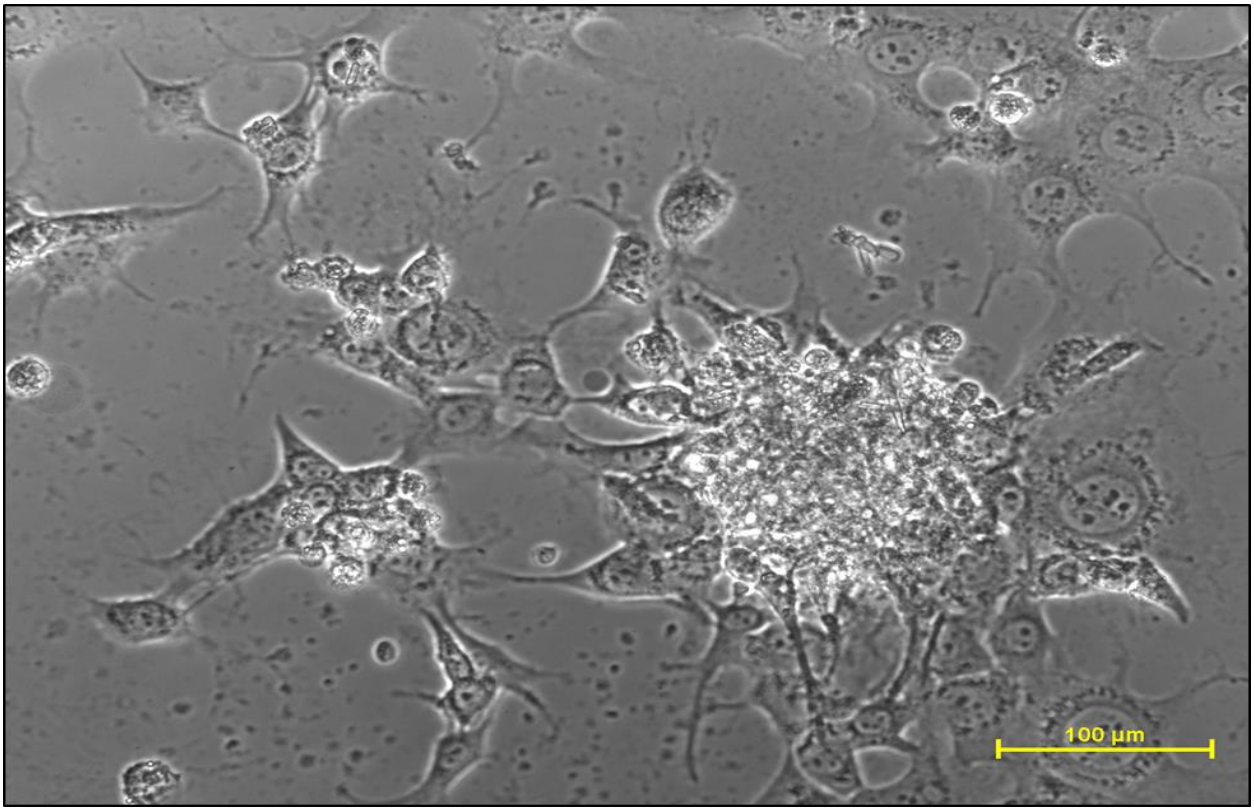


Figure. 10 (a) Image of Human Breast Cancer Cell Line MCF-7 (% Control Growth) treated with 10, 20, 40 and 80 µg/mL concentration of SB-PEG.

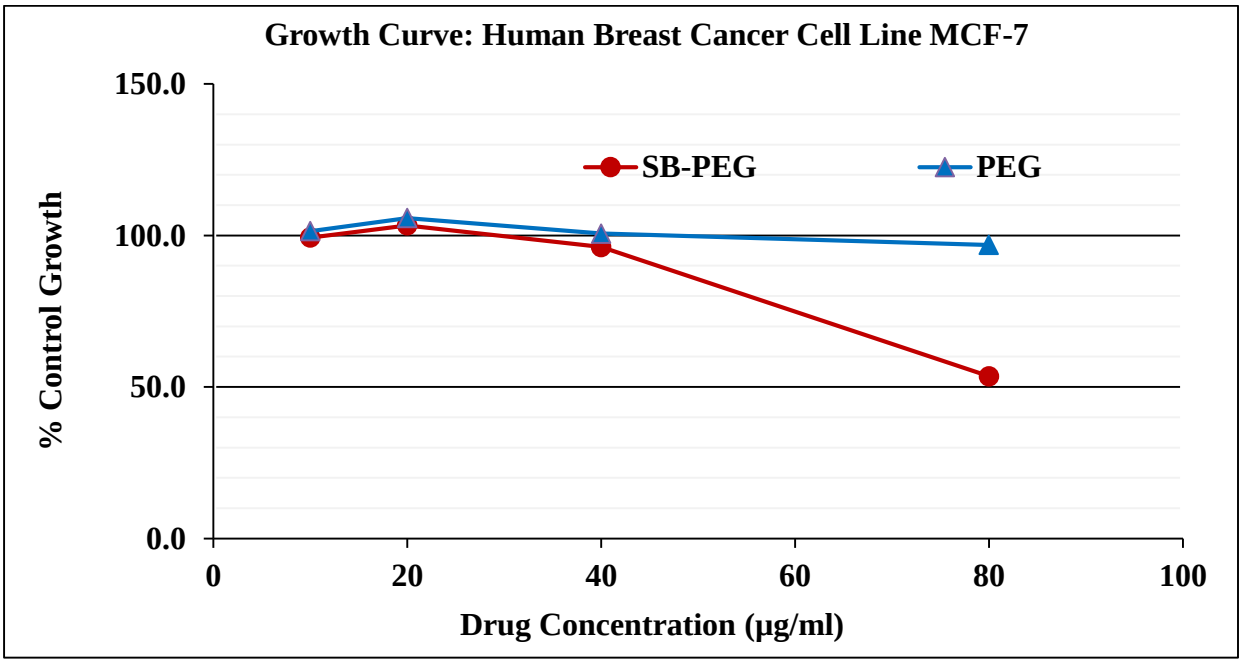


Figure. 10 (b) % Control Growth of Human Breast Cancer Cell Line MCF-7 treated with 10, 20, 40 and 80 µg/mL concentration of PEG and SB-PEG separately.

Physicochemical data of SB, PEG and Released SB from PEG in PD

Table 1: Density ($\rho \pm 10^{-3}$ kg m^{-3}), viscosity ($\eta \pm 10^{-5}$ mPa.s) and surface tension ($\gamma \pm 10^{-2}$mN m^{-1}) of pure water, PBS and PD at 303.15 K.

Pure solvents	ρ	η	γ
Water	0.993284	0.696000	70.00
PBS	0.993834	0.742281	99.95
PD	1.006841	0.863711	93.50

Table 2: Micro molar (μM), density ($\rho \pm 10^{-3}$ kg m^{-3}), viscosity ($\eta \pm 10^{-5}$ mPa.s), surface tension ($\gamma \pm 10^{-2}$mN m^{-1}), friccohesity (σ, $\pm 10^{-5}$s.m^{-1}), activation energy ($\Delta\mu^*_2 \pm 10^{-2}$ kJ mol^{-1}) and molecular radii (r, $\pm 10^{-2}$nm) at 303.15 K.

μM	ρ	η	γ	σ	$\Delta\mu^*_2$	r
SB-PD						
25	1.006124	0.861820	95.51	0.009579	64.01	15.82
50	1.006815	0.868044	95.58	0.009642	63.97	19.98
75	1.007523	0.873971	95.64	0.009701	63.94	22.92
100	1.008238	0.879981	95.71	0.009760	63.90	25.28
125	1.008929	0.885428	95.78	0.009814	63.86	27.29
150	1.009689	0.890989	95.85	0.009868	63.83	29.06
PEG-PD						
25	1.009065	1.071945	88.57	0.012848	62.71	17.01
50	1.009429	1.104110	88.60	0.013229	62.51	21.64
75	1.009799	1.137769	88.64	0.013627	62.31	25.03
100	1.010290	1.178845	88.68	0.014112	62.05	27.87
125	1.010642	1.212950	88.71	0.014515	61.84	30.31
150	1.010979	1.255509	88.74	0.015020	61.58	32.58

Table 3a: Limiting density (ρ°, kg m^{-3}), 1st slope (S_ρ, kg^{2}m^{-3}mol^{-1}), Limiting viscosity (η^o, mPa·s), 1st slope (S_η, mPa·s kg m^{-1}), Limiting surface tension (γ°,mN m^{-1}), 1st slope (S_γ, mN kg mol^{-1}m^{-1}).

System	ρ		η		γ	
	ρ°	S_ρ	η^o	S_η	γ°	S_γ
SB-PD	1.005398	0.000028	0.856305	0.000233	95.44	0.003
PEG-PD	1.008664	0.000016	1.031647	0.001469	88.53	0.001

Table 3b: Limiting friccohesity (σ^0,s.m^{-1}), 1st slope (Sσ, s.m.$^{-1}$kg^2 mol^2), Limiting activation energy ($\Delta\mu^*_2{}^0$, kJ mol^{-1}), 1st slope ($S_{\Delta\mu^*_2}$, kJ L/mM^2), Limiting molecular radii (r^0, nm), 1st slope (S_r, nm).

System	σ^0		$\Delta\mu^*_2{}^0$		r^0	
	σ^0	S_σ	$\Delta\mu^*_2{}^0$	$S_{\Delta\mu^*_2}$	r^0	S_r
SB-PD	0.009525	0.000002	64.04	-0.0014	14.34	0.10
PEG-PD	0.012371	0.000017	61.96	-0.0091	15.07	0.12

Table 3: Density (ρ± 10-3 kg m-3), viscosity (η ± 10-5 mPa.s), surface tension (γ ± 10-2mN m-1), friccohesity (σ, s.m^{-1}), activation energy (Δμ*2 ± 10-2 kJ mol-1) and molecular radii (r, nm) of SB released at 0 to 10 hrs from SB + TTDMM complexes at 303.15 K in phosphate buffer saline with 10 % DMSO.

Hrs	ρ	η	γ	σ	Δμ*2	r
0	1.008068	0.892161	89.09	0.010630	63.79	5.18
1	1.008525	0.894736	89.14	0.010656	63.80	5.19
2	1.008628	0.895056	87.93	0.010806	63.80	6.54
3	1.008791	0.890813	88.55	0.010680	63.83	7.47
4	1.008805	0.886028	88.55	0.010622	63.86	8.21
5	1.004748	0.827121	88.19	0.009956	64.23	8.65
6	1.005065	0.832276	88.83	0.009946	64.20	9.21
7	1.005358	0.831995	88.86	0.009940	64.20	9.69
8	0.999696	0.758297	88.35	0.009111	64.65	9.82
9	0.997233	0.731675	90.64	0.008570	64.82	10.10
10	0.997313	0.731011	90.64	0.008561	64.82	10.45

Table 4. Absorbance of pure SB concentration (μM) in phosphate buffer saline with 10 % DMSO.

μM	**SB**		
	245 nm	**285 nm**	**330 nm**
25	0.242	0.224	0.518
50	0.465	0.454	1.074
75	0.682	0.678	1.606
100	0.890	0.918	1.987
125	1.107	1.170	2.187

Table 5. Absorbance values of SB released at 0 to 10 h from SB-PEG complex at λ_{max} 245, 285 and 330 nm in phosphate buffer saline with 10 % DMSO.

h	**SB + PEG**		
	245	**285**	**330**
0	0.842	0.040	0.057
1	0.928	0.090	0.165
2	0.873	0.091	0.178
3	0.854	0.063	0.175
4	0.889	0.102	0.201
5	0.764	0.041	0.107
6	0.742	0.122	0.141
7	0.712	0.045	0.063
8	0.523	0.021	0.020
9	0.931	0.014	0.016
10	0.963	0.053	0.053

Table 6. The SB release (%) at 0 to 10 h from the PEG in phosphate buffer saline with 10 % DMSO at 37 ^{0}C at λ_{max} 245, 285 and 330 nm.

Hrs	**SB release (%)**		
	245 nm	**285 nm**	**330 nm**
0	38.50	18.29	26.06
1	42.43	41.15	75.45
2	39.92	41.61	81.39
3	39.05	28.81	80.02
4	40.65	**46.64**	**91.91**
5	34.93	18.75	48.93
6	33.93	55.78	64.47
7	32.56	20.58	28.81
8	23.91	09.60	09.14
9	42.57	06.40	07.32
10	**44.03**	24.23	24.23

Sheet B

Impact of biocompatible polyethylene glycol polymer on binding and releasing activities of silibinin anticancer drug moderated through physicochemical properties

Sachin B Undre, Tejas H Pavagadhi*

Centre of Research, Department of Chemistry, Indian Institute of Teacher Education, Gandhinagar-382016, India

Email: sachincug@gmail.com, *drtejaspavagadhi@gmail.com

Abstract

Silibinin (SB), a flavonoid with an eminent anticancer activity, not freely soluble in water and poses restrictions over its biomedical applications. Considering this as a potential challenge, the SB binding and corresponding release studied with polyethylene glycol (PEG) polymer is reported. The SB binding with PEG having long carbon chain and terminal -OH attached groups are attained from XRD, NMR, FTIR, DLS, SEM and physicochemical studies. The physicochemical properties (PCPs) such as density (ρ,$\pm 10^{-3}$ kg m^{-3}), viscosity (η, $\pm$ 10^{-4} mPa.s), surface tension ($\gamma \pm 0.01$ mNm^{-1}), friccohesity (σ, $\pm$ $s.m^{-1}$ 10^{-5}), activation energy ($\Delta\mu_2^* \pm 10^{-2}$kJ/mol) and particle size (r $\pm$ 0.01nm) of PEG-SB and released SB from PEG in appropriate solvents were determined for binding and releasing activity. Further, the released SB were studied using UV-Vis spectroscopy and depicted *in vitro* SB ≈ 9 %/h release in PBS + 10 % DMSO (PD) medium at 37 ^{0}C. The results of this study can provide new insights in the development of polymeric drug delivery systems for SB with a controlled and sustained release tendency. Further, SRB assay investigation showed that SB could mediate the anticancer effect at 80 µg/mL concentrations with 50% control growth inhibition of MCF-7 human breast cancer cell when it is bind with PEG

Keywords: PEG Polymer; silibinin anticancer drug; drug carrier; in vitro release activity; polymeric chain activities

Annexure -I

CENTRE OF RESEARCH
INDIAN INSTITUTE OF TEACHER EDUCATION
Ramkrushna Paramhans Vidya Sankul,
Near KH-5, KH- Road, Sector-15
Gandhinagar, Gujarat -382016
Final Report of the work done on the Minor Research Project

1. **Project report:** Final
2. **Reference No:** IITE/920/2016 dated 25/11/2016
3. **Period of report:** From 03/12/2016 to 18/07/2017
4. **Title of research project**: "Biocompatible polymers for binding and releasing capacities of anticancer drugs studied by using Survismeter"
5. **(a) Name of the Principal Investigator:** Dr. Tejas H. Pavagadhi
   (b) Name of the Co-Investigator: Dr. Sachin B. Undre
   (c) Dept. and University/College where work has progressed: Department of Chemistry, IITE, Gandhinagar
6. **Effective date of starting of the project:** 03/12/2016
7. **Grant approved and expenditure incurred during the period of the report:**
   (a) Total amount approved: Rs.25,000/-
   (b) Total expenditure: Rs. 0,0 /-
   i. **Report of the work done:** The detailed findings of research work is given in sheet A.
   ii. **Brief objective of the project**

The development of a new and novel formulations and their characterization is significant and will be an additional benefit to decide the multifunctional applications in the field of biochemical and biomedical sciences. In earlier reported work, conducted by various research scientists, many biocompatible polymers have been synthesized and characterized using spectroscopic, thermal and physicochemical techniques. Also the biocompatible polymers are suitable for the drug delivery systems.

Their physicochemical properties required for drug designing have been reported. We plan to develop formulation by using biocompatible and water soluble PEG polymer with higher hydrophilic functionality molecules for SB drug as drug delivery system. This PEG polymer will be studied for binding and releasing activities of anticancer drugs. We would focus on the anticancer applications which could lead to hinder the growth of cancerous cells and thus will become a benefit for biological sciences. Drug delivery is becoming a major challenging problem

today and high dosage is even causing side effects. Thus, our main objectives are (a) sustain drug delivery (b) minimize the dosage (c) reduce the side effect/s and (d) enhance the efficacy of the anticancer drugs.

Our research project will introduce several new and simple methods for PEG polymer with branching units and their applications as drug vehicles in the field of drug delivery systems.

iii. Work done so far and results achieved and publications, if any, resulting from the work (Give details of the papers and names of the journals in which it has been published or accepted for publication):

1. Impact of biocompatible polyethylene glycol polymer on binding and releasing activities of silibinin anticancer drug moderated through physicochemical properties. The prepared abstract is given in sheet B. (**Manuscript under preparation for communication**).

iv. Has the progress been according to original plan of work and towards achieving the objective. if not, state reasons:

Objective has been achieved.

v. Please indicate the difficulties, if any, experienced in implementing the project:

Since, the project was depending on the physicochemical properties and for determination of such properties, the Survismeter was required. We have arranged Survismeter, but the developed drug release experiment was innovative and for optimization, time required was more. Thus, the project was delayed by 45 Days.

vi. If project has not been completed, please indicate the approximate time by which it is likely to be completed.

NA

vii. If the project has been completed, please enclose a summary of the findings of the study.

Summary of the findings of the study is attached herewith in sheet A.

viii. Any other information which would help in evaluation of work done on the project. At the completion of the project, the first report should indicate the output, such as (a) Manpower trained (c) Publication of results (d) other impact, if any

a) Two faculties were trained during the project work.
b) One research paper is under preparation for communication.
c) The chosen PEG and their structural and physicochemical studies have proven that the PEG as excellent drug vehicles for silibinin, anticancer drug. This PEG

with mechanical linear branches and functional group were referred to as binders, which assisted in the trapping of targeted anticancer drugs for successful drug impacts on diseases like cancer with enhancing water solubility of hydrophobic drugs. The obtained results revealed that the PEG has excellent binding and releasing activities to minimize the dosage, reduce the side effect and enhance the efficacy of the anticancer drugs for curing the disease. The new concept based on linear branching units and attached functional group of the PEG have been coined as binding zones that indirectly explain the mechanism of PEG working in areas of nanomaterials and drug delivery systems. The fundamental knowledge gathered on developing drug-polymer complex and their characterization methods have concluded to propose a intermolecular molecular interaction model to monitor and develop confirmatory states of the proteins and polymeric materials.

Dr. Tejas H. Pavagadhi
Principal Investigator

Dr. Sachin B. Undre
Co-Investigator

Annexure–II

CENTRE OF RESEARCH
INDIAN INSTITUTE OF TEACHER EDUCATION
Ramkrushna Paramhans Vidya Sankul,
Near KH-5, KH- Road, Sector-15
Gandhinagar, Gujarat -382016

PROFORMAFORSUBMISSIONOFINFORMATIONATTHETIMEOFSENDINGTHEFINAL REPORT OFTHEWORKDONE ONTHEPROJECT

1. **Name of the principal investigator:** Dr. Tejas H. Pavagadhi

2. **Name of the Co-investigator:** Dr. Sachin B. Undre

3. **Name and address of the institution/university:** Department of Chemistry, Indian Institute Teacher Education, Sector-15, Gandhinagar-382016

4. **University approval no. and date:** IITE/920/2016 dated 25 Nov 2016

5.Date of implementation: 3rd Dec 2016.

5.Tenure of the project:6 Months

6.Total grant allocated: Rs. 25,000/-

7.Total grant received: Rs.0,0/-

8.Final expenditure: NIL

9.Title of the project: "Biocompatible polymers for binding and releasing capacities of anticancer drugs studied by using Survismeter"

10.Objectives of the project:

The development of a new and novel formulations and their characterization is significant and will be an additional benefit to decide the multifunctional applications in the field of biochemical and biomedical sciences. In earlier reported work, conducted by various research scientists, many biocompatible polymers have been synthesized and characterized using spectroscopic, thermal and physicochemical techniques. Also the biocompatible polymers are suitable for the drug delivery systems.

Their physicochemical properties required for drug designing have been reported. We plan to develop formulation by using biocompatible and water soluble PEG polymer with higher hydrophilic functionality molecules for SB drug as drug delivery system. This PEG polymer will be studied for binding and releasing activities of anticancer drugs. We would focus on the anticancer applications which could lead to hinder the growth of cancerous cells and thus will become a benefit for biological sciences. Drug delivery is becoming a major challenging problem

today and high dosage is even causing side effects. Thus, our main objectives are (a) sustain drug delivery (b) minimize the dosage (c) reduce the side effect/s and (d) enhance the efficacy of the anticancer drugs.

Our research project will introduce several new and simple methods for PEG polymer with branchings units and their applications as drug vehicles in the field of drug delivery systems.

11. Whether objectives were achieved(give details): Yes, the objectives are achieved.

12.Achievements from the project:

The PEG was used for the silibinin binding and releasing activity in this project work and their structural characterization was made by using various spectroscopic techniques. Their physicochemical properties which were measured with Borosil Mansingh Survismeter show that the intermolecular interactions between the endgroup and the foreign molecules such SB anticancer drugs. This PEG with linear branching chain having –OH functional group with enhancing the structural activities which are asset for developing the application for drug binding and loading with controlled release. The PEG for anticancer SB drug binding and releasing activities were studied by using various instrumental techniques and physicochemical characterization. And it was found that the PEG polymer with mechanical linear branch was referred to as tentacles, which assisted in the trapping of targeted silibinin for successful drug impacts on diseases like cancer. The presence of linear branched chain with hydrophilic zones of PEG assists in conjugating drug molecule, which is greatly useful in drug delivery systems. They could be asset for developing applications in bioremediation, biomedical, biochemical process and drug delivery systems.

13.Summary of the findings (in 500words): The summary of the finding is attached on sheet A.

14.Contribution to the society (Give details):

The PEG polymer molecule in the project have been studied for their successful binding and loading capacities of silibinin anticancer drug. The anticancer applications could lead to less growth of cancerous cells and thus has become a boon for the society. Initiation in the production and growth of polymer itself is an objective to establish the science of new molecule and the development process as a new process in the society. Drug delivery is becoming a major problem today and high dosage is even causing side effects.

The PEG is helpful to minimize the dosage and reduced the side effect that is caused. The PEG polymer having excellent features of binding and releasing activities for anticancer drugs which is applicable in the development of the society. How does the

advanced PEG polymer with higher hydrophilicity are developed, the hypothesis for this methodology was formulated to an advanced level. Similarly, the methods and techniques for their characterizations and applications have been developed for emerging new interfaces and interochemistry.

15. **No. of publications out of the project (please attach re-prints):** One research paper entitled **"Impact of biocompatible polyethylene glycol polymer on binding and releasing activities of silibinin anticancer drug moderated through physicochemical properties"** published is under preparation for communication. The prepared abstract is given in sheet B.

Dr. Tejas H. Pavagadhi
Principal Investigator

Dr. Sachin B. Undre
Co-Investigator

Annexure-III

CENTRE OF RESEARCH
INDIAN INSTITUTE OF TEACHER EDUCATION
Ramkrushna Paramhans Vidya Sankul,
Near KH-5, KH- Road, Sector-15
Gandhinagar, Gujarat -382016

Utilization certificate

This is Certified that the grant of Rs. 25,000/- (Rupees twenty-five thousand only) sanctioned from Centre of Research, IITE under the scheme of support for Minor Research Project Entitled "Biocompatible polymers for binding and releasing capacities of anticancer drugs studied by using Survismeter" (Vide letter No. F. IITE/920/2016 dated 25 Nov 2016). Since we have utilized the available resources in the Chemistry Laboratory along with outside resources for completion of Minor Research Project work. Hence, total expenditure for the project work is **Nil (Rs.0.0)**. Thus, the sanctioned amount of **Rs. 25,000/- did not utilized** for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the Centre of Research, IITE, Gandhinagar.

Dr. Tejas H. Pavagadhi
Principal Investigator

Dr. Sachin B. Undre
Co-Investigator

Indian Institute of Teacher Education (IITE)
Centre of Research

Ref. No.: IITE/(COR)/IMO/2016 Date: 15/12/2016

To,
Dr. Jumisree Sarmah Pathak
The Principal Investigator
Head, Department of Physics
Centre of Education
IITE, Gandhinagar

Sub: Minor Research Project entitled "Anomalous variation in Global Positioning System (GPS), Total Ionospheric Electron Content (TEC), Land and Ocean parameters prior to some earthquakes"

Dear Madam,

This is in reference to the above cited research proposal submitted for financial support under **Minor Research Project Scheme** of Centre of Research, IITE, Gandhinagar. In this context, it is to inform you that the above mentioned research project has been approved for financial support of **Rs. 25,000/-** by Hon'ble Vice-Chancellor, IITE Gandhinagar on the basis of the recommendations made by the experts during Project Evaluation Committee held on 1st December, 2016. The financial support in the form of contingency grant is given to meet the necessary expenditure towards photocopies and microfilms, typing, stationary, postage, telephone and fax cost, internet cost, computation and printing needed for the project work.

The investigators of this project has been suggested to submit the budgetory stretagy for the utilization of the fund of MRP with the cosultation of Coinvestigator. The commitee members also pointed out that the proposed research project work should not be the repeatation of the .Ph. D. work done by PI or Coi

In this connection you are requested to submit your acceptance in written to carry out the said project along with undertaking to follow the terms and conditions as per Annexure I enclosed herewith. The time frame of this Minor Research Project is not more than five months from the date of submission of your acceptance.

Thanks and regards.

15/12/16

University Development Officer

IITE, Gandhinagar

Copy to:

1. Dr. Kunvar S. Yadav, Asst. Prof.,Dep t.,of Physics Coinvestigator
2. Principal, Centre of Education
3. Director, Centre of Education
4. Director, Centre of Extension
5. Director, Centre of Skill & Training
6. P. A. to VC
7. Finance Officer
8. Office File