Siberian Federal University

Physical Chemistry of Oil Dispersed Systems

Course (module) Title

Physical Chemistry of Oil Dispersed Systems

Course (module)

Krasnoyarsk, 2020

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Course (module) Guide Physical Chemistry of Oil Dispersed Systems

1. Course (module) Description

1.1. Course (module) overview

The course of Chemistry of Oil Dispersed Systems provided a curriculum of postgraduate educational program 04.06.01 Chemical Sciences; specialization is 12.00.13 Petroleum Chemistry.

The course gives broad information about the modern approach to investigation of crude oils. The oil dispersed systems may be defined as dealing with at least two immiscible phases in contact; therefore, the understanding of physical, chemical, and/or physical-chemical phenomena that occur at interfaces or at the layers close to the interfaces, is of substantial interest. Crude oil recovering and processing lead to changing in the oil dispersed system which can have either positive or negative effects. The course teaches postgraduate students to take into count features of the oil dispersions while researching on the topic of dissertation thesis is conducted. The postgraduate students acquire the competencies and skills in the field of regulating the stability of oil dispersed systems, their thermodynamic and kinetic patterns, rheological properties, features of structure formation which makes it possible to analyze the patterns of oil dispersed systems behavior from the moment of formation in crude oils recovering to them refining.

1.2. Special features of the course (module)

1. Special theoretical information about the oil dispersed systems, presented as part of the subject, is a necessary component of a graduate student preparation for the implementation of teaching activities in educational programs of higher education in the field of chemical sciences.
2. The course of Chemistry of Oil Dispersed Systems presents the current statues of the problems in the scientific specialty 02.00.13 "Petroleum chemistry", and also demonstrates to the student the actual problems of this science, which is a necessary component of the graduate student preparation for the implementation of research activities in the field of chemical sciences.
3. The discipline of Chemistry of Oil Dispersed Systems is included to the block of the variable part marked Disciplines of Choice of the curriculum for training scientific and pedagogical personnel and is implemented during one semester of the first academic year.

1.3. Course (module) aim

- To acquaint with the main theoretical schools, approaches and concepts for solving problems in the field of dispersion phenomenon and surface processes physical chemistry.
- To form abilities to search, analyze, critically reflect and generalize scientific and technical information, approve the results of research work.
- To provide knowledge which allow to estimation complex impacts of oil dispersed system to crude oil recovering and processing.

1.4. Course (module) objectives

- Obtaining knowledge about the formation, classification, stability of the oil dispersed systems;
- Study of the structure formation features and regulation of the oil dispersed systems properties;
- Getting acquaint with the synthesis methods of some petrochemical products in the laboratory.
- Formation of the professional understanding ability and solution of the main problems of stability of oil dispersed systems.
- Formation postgraduate students' capacity to search, analyzes, critically understand and generalize scientific and technical information, formalize the results of research work.

1.5. Learning outcomes of the course (module)

By the end of the course, postgraduate students will be able to:

- know patterns of supramolecular structures formation and regulation, classification, stability of the oil dispersed systems, their thermodynamic and kinetic patterns, and rheological properties;
- apply the modern models to describe the rheological behavior of dispersed systems, analyze the patterns of behavior of the oil dispersed systems;
- possess preparation and research methods of the oil dispersed systems physicochemical and technological properties, the basics of thermodynamic description of the petroleum dispersed systems

properties;

1.6. Teaching and Learning Methods

The course includes methodological information which will be educated by the students themselves, practice sessions and seminars session which is realized by distant form through electronic resources that are associated with the SFU or in lecture halls of «Basic chair of chemistry and technology of natural energy resources and carbon materials»

2. Course Instructor(s) and Tutor(s), Contact Information

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3. Prerequisites

Master's degree in Petroleum Engineering, Engineering, Chemistry, Environmental Sciences or equivalent (transcript of records), good command of English (certificate or other official document).

4.1 Course (module) requirements

4.1.1. Required text(s)

Main literature

1. Modern Chemical Enhanced Oil Recovery: theory and practice [Text]: Учебник / J.J. Sheng - Amsterdam: Elsevier, 2007. - 316 с.
2. The chemisty and technology of petroleum [Text] / J. G. Speight. - 4th ed. - Boca Raton ; London ; New York : CRC Press : Taylor & Francis Group, 2006. - 919 p.

3. Applied process design for chemical and petrochemical plants [Electronic resource]. Vol. 1 / E. E. Ludwig. - 3th ed. - Electronic text data (28,8 МБ). - Boston : Butterworth-Heinemann, 1999. - 630 p.
4. Applied process design for chemical and petrochemical plants [Electronic resource]. Vol. 2 / E. E. Ludwig. - 3th ed. - Electronic text data (38,3 МБ). - Boston : Butterworth-Heinemann, 1999. - 486 p
5. Applied process design for chemical and petrochemical plants [Electronic resource]. Vol. 3 / E. E. Ludwig. - 3th ed. - Electronic text data (24,4 МБ). - Boston : Butterworth-Heinemann, 1999. - 690 p.
6. Handbook of Vinyl Polimers. Radical Polymerization, Process and Technology [Text]: monograph / Y. Vagci; Ed. M.K. Mishra. - 2nd ed. - London: CRC Press, 2009. - 763 p.
7. Handbook of MTBE and Other Gasoline Oxygenates [Text] / ed.: H. Hamid, M. Ashraf Ali. - New York : Marcel Dekker, 2004. - 381 p.
8. Polymer Chemistry [Text]: monograph / W. R. Moore. - London: University of London Press LTD, 1967. - 270 p.

The list of information and telecommunication resources required for mastering the discipline (module) is available via Internet network

1. www.eLIBRARY.RU - Scientific electronic library. Access mode is free.
2. www.sciencedirect.com - Elsevier Database. Access mode is free.
3. www.nature.com - Scientific journal Nature. The access mode is free.
4. www.scopus.com - Scopus peer-reviewed literature database. Access mode is free.
5. www.springerlink.co - Springer Database.
6. www.isiknowledge.com - Web of Science Database. Access mode is free.

4.1.2 Web page of the course (module)

You can receive the information about the postgraduate program 02.00.13 Petroleum Chemistry and about the course Physical Chemistry of Oil Dispersed Systems in SibU website: www.e.sfu-kras.ru. You must be logged in to access the materials. Course materials and required reading materials are available at the internet resources that are associated with the SFU.

4.1.3. Course (module) materials (seminar notes, assignments for classroom activities and sessions)

Prior to attending the lections some preparation can be very valuable.

Consultation on the Physical Chemistry of Oil Dispersed Systems module is carried out by electronic resources that are associated with the SFU or face-to-face. There are various materials for self-preparation, for lections or practical classes, which are available a week before the class on the web page of the discipline provided by My SFU Resource. The materials can be in form of simple text documents while others may be audio or video files, or online exercises. Most of them are supplementary intended for independent study and are not supposed to replace the practical sessions. The great benefit is that you can return and revisit them when you want. Home assignments involve printed reports, oral or visual presentations.

4.1.4 Required feedbacks

The supervisor might use the web page of the module Physical Chemistry of Oil Dispersed Systems located on My SFU Resource as a communication channel. It is important that you become familiar with checking and accessing it regularly. Make sure that you have access to the correct module pages, and get in touch with your lector or programmer administrators in any other cases.

The postgraduate students must be ready to discuss the aim and methodology of them own research activities in the field of petroleum chemistry. They have to justify a selection of appropriate laboratory or technological methods that have been chosen for a research implementation. The discussion is realized via face-to-face discussion or via the electronic resources.

4.2. Course (module) Structure

4.2.1 Internal education

Learning activities	Total credits (academic hours)	Semester
		3
Total	3 cr. (108 a. h.)	3 cr. (108 a. h.)
Lectures	0,77 cr. (28 a. h.)	0,77 cr. (28 a. h.)
Self-study of the students:		
Study of the theoretical course (including preparation for final attestation)	2,22 cr. (80 a. h.)	2,22 cr. (80 a. h.)
Final Attestation	credit	credit

4.3 Time schedule course (module) and course (module) outline

4.3.1 Internal education

№	Topic	week, №	Learning Activities (lecture, lab, class assignments, assessment and other)	Hours	Self-study Assignments	Reading
1	Classification of the oil dispersed systems	1	**Lecture 1.** Classification of the oil dispersed systems.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	The literature listed in 4.1 paragraph. The articles and materials are indexed by Scientific Databases listed in 4.1 paragraph.
		2	**Lection 2.** Classification of the oil dispersed systems according to the state of the dispersed phase and dispersion medium.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	
		3	**Lection 3.** Classification of the oil dispersed systems according to the degree of dispersion and interphase interaction, according to the shape of the particles which is formed them.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	
2	Intermolecular interactions of oil components	4	**Lection 4.** Intermolecular interactions of the oil components.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	The literature listed in 4.1 paragraph. The articles and materials are indexed by Scientific

		5	**Lection 5.** Thermo-dynamic characteristics of the oil dispersed systems	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	Databases listed in 4.1 paragraph.
		6	**Lection 6.** Thermo-dynamic and kinetic regularities of the oil dispersed systems.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	
		7	**Lection 7.** Methods of the oil dispersed systems formation.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	
		8	**Lection 8.** Formation and structure of complex structural units.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	
		9	**Lection 9.** Energy interactions and the size of complex structural units in the oil dispersed systems.	2	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	

3	Physicochemical mechanics and rheology of the petroleum dispersed systems	10-11	**Lection 10 - 11.** Rheological properties of the oil dispersed systems.	4	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	The literature listed in 4.1 paragraph. The articles and materials are indexed by Scientific Databases listed in 4.1 paragraph.
		12-13	**Lection 12 - 13.** Practical application of the physical and chemical mechanics principles of the oil dispersed systems.	4	Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	
4	Final attestation	15	**Credit**			

5. Assessment

5.1 Form of assessment

Home assignment will involve some form of printed and oral reports, or downloadable file on the web page of the discipline (for distant education) within the specified period. The students must realize successfully not less than 6 oral reports during the course. This requirement does not depend on the form of education (distant or internal).

5.2 Grading scale

Grade policy for both home assignments and the final credit is:

- A (excellent work) 91–100 points
- B (above average work) 81–90 points
- C (average work) 71–80 points

- D (below average work) 50–70 points
- F (failed work) < 50 points

Students are assessed by results of practical work, tests, and a final attestation. Progress assessment:

- 50 % home assignments;
- 50 % credits.

6. Attendance Policy

Students are expected to attend and participate in classes and should notify lecturer of excused absences in advance, where possible. Students who have an excused absence are expected to make arrangements with lecturer for alternative assignment.

Every topic has a home assignment work that should be done. The final mark will be made by the same grade policy as for a final credit.

7. Required Course (module) Participation

Students should be able to:

- defend the writing reports (50 points maximum),
- write an answer on 2 questions, demonstrate covered material (50 points maximum).

8. Facilities, Equipment and Software

The implementation of the course provides for the availability of lecture rooms (personal computers, printers, copier, projector, demonstration materials) with access to webpages of the E-learning SibFU through web site: www.sfu-kras.ru. The training process for this course uses standard Microsoft Office programs.

List of required software.

1. Windows XP or later operating system from Microsoft® Windows family.
2. Microsoft® Office Professional Plus 2010 Russian Academic OPEN No Level.
3. ESET NOD32 Antivirus Business Edition for 2750 users.
4. Adobe Acrobat Pro Extended 9.0 WIN AOO License IE Acrobat Pro Extended, License Certificate from Softline (10.12.2008, indefinitely).

5. Ascon Compass-3D, License Certificate №E-08-000123 (11.09.2008); №E-7-00107 (12.12.2017, indefinitely).
6. AutoCAD, free software.

Annex 1. Example of Questions to the Credit

1. Classification of oil disperse systems and its basic properties.

2. The difference between physical and chemical bonds. Calculation of the total energy of chemical compounds intermolecular interaction. Phase transitions of the first and second kind.

3. Kinds of intermolecular interactions during the formation of the oil dispersed systems. Influence of intermolecular interactions on the properties of molecular solutions and oil dispersed systems.

4. Thermodynamic foundations of phase formation the oil dispersed systems. Thermodynamics of physical and chemical transformations.

5. Features of the structures of asphaltenes. Concepts of the primary structural units of the oil dispersed systems, molecular structures.

6. Ordered and unordered structures. The degree of regularity.

7. Transition of the oil structure from a nonequilibrium state to an equilibrium one.

8. Influence of the structure of paraffinic hydrocarbons, asphaltenes and resins on the dispersed state of oil and oil products.

9. Methods of obtaining the oil dispersed systems. Dispersion of macroscopic phases and condensation from molecular solutions.

10. Types of local formations in oil systems. The structure of a complex structural unit. The core is a solvation layer. Radii of the core and the solvation layer.

11. Energy interactions and sizes of complex structural units in oil dispersed systems.

12. Theory of regulated phase transitions. Criteria for spontaneous formation and dissolution of supramolecular structures in a dispersion medium.

13. Dissolution of associates. Structured and structureless systems. Modern methods for conducting of the oil dispersed systems research.

14. Stages of the dispersed state. Factors affecting the stability of dispersed systems. Methods for determining and regulating the stability of the oil dispersed systems.

15. States of the dispersed phase and environment in oil and oil products.

16. Physicochemical mechanics of the oil dispersed systems in the field of oil production, transportation and refining.

17. Rheology and viscosity in the theory of oil dispersed systems. Methods for describing the mechanical properties of the oil dispersed systems. Regulation of rheological properties of the oil dispersed systems.

18. Extreme states of oil dispersed systems.

19. Water-oil emulsions. Influence of surface activity of surfactants on the stability of emulsions.

20. Gas emulsions. Foaming agents. Stability of gas emulsions.

Annex 2. Example of Self-Study Assignment

1. The solubility of sodium chloride in water at 290 K is 35.8 kg/100 kg of water. Express the solubility as the following:

(a) Mass fraction and mass percent of NaCI

(b) Mole fraction and mole percent of NaCI

(c) kmol NaCI per 1000 kg of water

2. Determine the volume of oxygen obtained under standard conditions, by the decomposition of 100 kg of potassium chlorate.

3. The capacity of the tubular ethylene polymerization reactor at 170 MPa is 6,000 kg of polyethylene per hour. The reactor has a diameter of 0.06 m and a length of 1000 m. Determine the volumetric feed rate of ethylene (at the stated pressure and gas temperature 190 ° C), if the ethylene conversion is 12.5%.

4. One way to obtain Acrylonitrile (monomer for the production of Nitron fiber) is the oxidative ammonium propylene. On oxidative ammonium received: 1254 kg of propylene; 2360 kg of oxygen; 516 kg of ammonia and water vapor. It was obtained 1000 kg of Acrylonitrile, as well as a number of by-products: acrolein, hydrocyanic acid, acetonitrile, methane and carbon dioxide. At the same time, part of propylene and oxygen were not reacted — respectively 161 kg and 903 kg.Calculate the yield of Acrylonitrile from the theoretically possible, the conversion of propylene and oxygen. Write the equation of the target reaction and reactions of formation of by-products.

Course Physical Chemistry of Oil Dispersed Systems

Basic Information

This is a course, which contributes to postgraduate educational program 04.06.01 Chemical Sciences, specialization is 12.00.13 Petroleum Chemistry.

Course period	From February 1st till May 31st, 4 semester (15 weeks)
Study credits	3 ECTS credits
Duration	108 hours
Language of instruction	English
Academic requirements	– M. Sc degree in Petroleum Engineering, Engineering, Chemistry , Environmental Sciences or equivalent (transcript of records), – good command of English (certificate or other official document)

Course Description

The course of Chemistry of Oil Dispersed Systems provided a curriculum of postgraduate educational program 04.06.01 Chemical Sciences; specialization is 12.00.13 Petroleum Chemistry.

The course gives broad information about the modern approach to investigation of crude oils. The oil dispersed systems may be defined as dealing with at least two immiscible phases in contact; therefore, the understanding of physical, chemical, and/or physical-chemical phenomena that occur at interfaces or at the layers close to the interfaces, is of substantial interest. Crude oil recovering and processing lead to changing in the oil dispersed system which can have either positive or negative effects. The course teaches postgraduate students to take into count features of the oil dispersions while

researching on the topic of dissertation thesis is conducted. The postgraduate students acquire the competencies and skills in the field of regulating the stability of oil dispersed systems, their thermodynamic and kinetic patterns, rheological properties, features of structure formation which makes it possible to analyze the patterns of oil dispersed systems behavior from the moment of formation in crude oils recovering to them refining.

Special Features of the Course

- Special theoretical information about the oil dispersed systems, presented as part of the subject, is a necessary component of a graduate student preparation for the implementation of teaching activities in educational programs of higher education in the field of chemical sciences.
- The course of Chemistry of Oil Dispersed Systems presents the current statues of the problems in the scientific specialty 02.00.13 "Petroleum chemistry", and also demonstrates to the student the actual problems of this science, which is a necessary component of the graduate student preparation for the implementation of research activities in the field of chemical sciences.
- The discipline of Chemistry of Oil Dispersed Systems is included to the block of the variable part marked Disciplines of Choice of the curriculum for training scientific and pedagogical personnel and is implemented during one semester of the first academic year.

Course Aims

- To acquaint with the main theoretical schools, approaches and concepts for solving problems in the field of dispersion phenomenon and surface processes physical chemistry.
- To form abilities to search, analyze, critically reflect and generalize scientific and technical information, approve the results of research work.
- To provide knowledge which allow to estimation complex impacts of oil dispersed system to crude oil recovering and processing.

Course Objectives

– Obtaining knowledge about the formation, classification, stability of the oil dispersed systems;

– Study of the structure formation features and regulation of the oil dispersed systems properties;

– Getting acquaint with the synthesis methods of some petrochemical products in the laboratory.

– Formation of the professional understanding ability and solution of the main problems of stability of oil dispersed systems.

– Formation postgraduate students' capacity to search, analyzes, critically understand and generalize scientific and technical information, formalize the results of research work.

Learning Outcomes of the Course

By the end of the course, students will be able to:

– analyze the chemical processes and phenomena according to the main theoretical schools, approaches, concepts for solving problems in the field of chemical technology of oil refining;

– know patterns of supramolecular structures formation and regulation, classification, stability of the oil dispersed systems, their thermodynamic and kinetic patterns, and rheological properties;

– apply the modern models to describe the rheological behavior of dispersed systems, analyze the patterns of behavior of the oil dispersed systems;

– possess preparation and research methods of the oil dispersed systems physicochemical and technological properties, the basics of thermodynamic description of the petroleum dispersed systems properties;

Course Outline

Week	Topic	Lections / Practice session / Assignments	Hours[1] (Internal education)
1-3	Classification of the oil dispersed systems	**Lecture 1.** Classification of the oil dispersed systems. **Lection 2.** Classification of the oil dispersed systems according to the state of the dispersed phase and dispersion medium. **Lection 3.** Classification of the oil dispersed systems according to the degree of dispersion and interphase interaction, according to the shape of the particles which is formed them. **Self-study assignments.** Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	2 2 2 26.7
4-9	Intermolecular interactions of oil components	**Lection 4.** Intermolecular interactions of the oil components. **Lection 5.** Thermodynamic characteristics of the oil dispersed systems **Lection 6.** Thermodynamic and kinetic regularities of the oil dispersed systems. **Lection 7.** Methods of the oil dispersed systems formation. **Lection 8.** Formation and structure of complex structural units. **Lection 9.** Energy interactions and	2 2 2 2 2 2

[1] Hours designed for Classroom sessions, Web-sessions, Home Assignments etc.

		the size of complex structural units in the oil dispersed systems. **Self-study assignments.** Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	26.6
10-14	Physicochemical mechanics and rheology of the petroleum dispersed systems	**Lection 10 - 11.** Rheological properties of the oil dispersed systems. **Lection 12 - 13.** Practical application of the physical and chemical mechanics principles of the oil dispersed systems. **Self-study assignments.** Exact topics for self-study assignments are depended on the line of academicals research that is conducted by the students.	4 4 26.7
15	Final attestation	**Credit**	

Lecturer and Contact Information

Leila Sultanovna Batalina

Associate Professor at School of Petroleum and Natural Gas Engineering, Siberian Federal University

(room 313) 82/6, Svobodny prospect, Krasnoyarsk, Russia.

Tel: +7(391) 2-062-879. E-mail: LBatalina@sfu-kras.ru

Assessment

Grade policy for both home assignments and the final credit is:

- A (excellent work) 91–100 points
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- C (average work) 71–80 points
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Web page of the course

You can receive the whole information about the postgraduate program 12.00.13 Petroleum Chemistry and about the course in SibU website: www.e.sfu-kras.ru. You must be logged in to access this course. Course materials and required reading materials are available at the course web-page.

Core reading

1. Modern Chemical Enhanced Oil Recovery: theory and practice [Text]: Учебник / J.J. Sheng - Amsterdam: Elsevier, 2007. - 316 с.
2. The chemisty and technology of petroleum [Text] / J. G. Speight. - 4th ed. - Boca Raton ; London ; New York : CRC Press : Taylor & Francis Group, 2006. - 919 p.

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6. Handbook of Vinyl Polimers. Radical Polymerization, Process and Technology [Text]: monograph / Y. Vagci; Ed. M.K. Mishra. - 2nd ed. - London: CRC Press, 2009. - 763 p.
7. Handbook of MTBE and Other Gasoline Oxygenates [Text] / ed.: H. Hamid, M. Ashraf Ali. - New York : Marcel Dekker, 2004. - 381 p.
8. Polymer Chemistry [Text]: monograph / W. R. Moore. - London: University of London Press LTD, 1967. - 270 p.

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2. www.sciencedirect.com - Elsevier Database. Access mode is free.
3. www.nature.com - Scientific journal Nature. The access mode is free.
4. www.scopus.com - Scopus peer-reviewed literature database. Access mode is free.
5. www.springerlink.co - Springer Database.
6. www.isiknowledge.com - Web of Science Database. Access mode is free.