+1-226-271-7206

info@nsric.ca

Toronto, ON, Canada

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Crude Oil Chemistry
(Module I – III)

1.0 Course Faculty Information

Name: Prof. Dr. A. K. Choubey
NSRIC Inc., Toronto, Ontario, Canada

2.0 Course Information

Course Codes	SCI--A-C00373
Class Days	Follow posting in NSRIC LMS system
Class Time	Follow posting in NSRIC LMS system
Course Credit Hours	3
Class Location	NSRIC online platform
prerequisites and/or co-requisites	n/a
Level /A, E, H, I, K12, M, P, S, T, U, V, W	Advanced level academic level courses / A

Note: The below classification of courses is related any areas of knowledge:
A: Advanced level academic level courses; **C**: Canadian immigration and training courses; **E**: Executive courses; **H**: Higher-level courses (i.e., graduate courses); **I**: Intermediate courses (i.e., university preparatory courses – Grade XII+); **K12**: Foundational, and lower-level courses; **M**: Mid-level courses (i.e., undergraduate courses); **P**: Professional courses; **S**: Short/seminar courses; **T**: Training courses; **U:** Tutorial Courses; **V:** Vocational training courses; and **W**: Workshop courses.

3.0 Professor Information

Name	Prof. Dr. A. K. Choubey
Title	NSRIC Professor in Chemistry
Contact Information	choubey.abhaykumar@gmail.com
Office Location	NSRIC online platform
Office Hours	11: 30 am – 1:00 pm EST (Monday) by email appointment

4.0 Target Audiences

- Chemists and lab technicians having job responsibility for analysis of crude oil.
- University graduate/undergraduate students of Chemical and Petroleum Engineering programs.
- Any student who is interested in Crude oil chemistry.
- Refinery personnel responsible for evaluating crude oils to determine their characteristics and analysis of refined petroleum products

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5.0 Course Modules Description or Course Description

Module I:

In crude oil chemistry, there is an inadequacy in understanding of fundamental part of various types of hydrocarbons and materials found present in crude oil and their nature. Those hydrocarbons are found present in subsurface location. Due to lack of knowledge of nature of those materials and further processing and complexity of refining processes of crude oils, refiners are not able to properly handle those materials for getting required petroleum products. After working on fractional distillation process for getting petroleum products, those fractions or cuts are characterized for getting valuable properties required for handling, storage and transmission. To date, for getting information about those fractions, several textbooks provide information about various characteristics of those petroleum and extracted products. Unfortunately, there are limited books or courses where limited study materials and exercises are available. As the first and only complete guide for refiners, chemists and lab technicians including petroleum engineering undergraduate and postgraduate students on a basic and in-depth understanding of hydrocarbons, this course is valuable and the greatest choice for the oil and gas industry community.

Module I includes all the basic aspects of **Constituents of Crude Petroleum:** Composition, classification and characterization, Natural gas constituents, Crude oil and gas stabilization. Pre-treatment of crude: Dehydration, desalting and distillation of crude petroleum. This module also covers **Petroleum Analysis and Evaluation:** Definitions of characteristics of petroleum and refined petroleum products, ASTM evaluation, Spectroscopic methods, Molecular weight, etc. The course comprises of Metals **and Hetero Atoms Presence in Heavy Crude Petroleum:** Hetero atom distribution in refinery distillation cuts, Molecular distillation fractions, SARA separation, Acids-bases-neutrals separations, Structures of hetero atom functions (sulphur, nitrogen, metal compounds, etc.) as well. The fundamental issues for beginners who are interested in learning about crude oil and its various important properties including ASTM/IP processes related to those important properties evaluation are through workout examples and self-practices to have a deep understanding on each of the processes. The course will provide the comprehensive informations in a clear manner so that the learners in crude oil chemistry would be able to understand chemistry of petroleum and the various fractions of petroleum alongwith the presence of hydrocarbons in them with minimum effort. This will make the students interested in enrolling for the course.

This module is an excellent source for chemical and petroleum engineering students, refiners, chemists and laboratory technicians who want to learn concepts through each chapter, exercises, and exercises for self-practices mode. The course is designed for audiences/students who have basic knowledge of hydrocarbons including aliphatic, aromatic compounds and organometallics as well.

The course contains three modules (Module I – III). The first module, Module I covers three chapters, Module II, two chapters and Module III, two chapters only. Students are strongly advised to complete the

Course, Crude Oil Chemistry by Prof. A. K. Choubey at NSRIC Platform to understand this course content.

Keywords:Petroleum, Crude Petroleum, Hetero Atoms, Chemical Operations, End Products, Feedstocks, Petrochemicals, Cracking, Naphtha, Natural Gas, Dehydration, Desalting, Distillation, ASTM evaluation, Refinery, Distillation cuts, Molecular distillation, SARA, Molecular weight, Molecular models, Petroleum products.

Module II:

In crude oil chemistry, there is a shortcoming in understanding of asphaltenes, refractory materials, which are found present in crude petroleum especially in heavy crude oils and crude selection for refinery processing including blending of stocks to meet product specifications. Testing and uses of petroleum products are also not so simple. Handling and processing of asphaltenes are not a simple task due to the lack of enough knowledge of their nature and processing. To date, there are limited textbooks that explain and cover fundamentals and in-depth of processing techniques based on ASTM and IP processes. There are no specific books on this where enough study materials, workout examples and exercises are available. This offered course will be able to help much for the aspirants.

Module II comprises of Asphaltenes and Structure of Petroleum: Separation, composition, structure studies, molecular weight, molecular models, etc. and Physical and Chemical Operations to Produce End Products: Crude selection for refinery processing: Blending of stocks to meet product specifications, testing and uses of petroleum products. The course covers the fundamental and in-depth knowledge for the professionals and students who are interested in learning crude petroleum chemistry through enough workout examples in each chapter, exercises, and exercises for self-practices to have a deep understanding on topics. The course presents the terminologies in a clear manner so that the beginner would be able to understand the complete hydrocarbon chemistry with minimum effort. This will make the students and professionals interested in enrolling the course. This module is a foundation, resource guide and an excellent source for chemical and petroleum engineering students and refiners including laboratory professionals.

Keywords: Asphaltenes, Petroleum, Crude petroleum, Heteroatoms blending, Product specifications, Testing.

Module III:

In crude oil chemistry course, there is a deficiency in understanding of Selection and Conversion of Petroleum Feedstocks to Petrochemicals: Cracking, oxidation, hydrogenation, alkylation, dealkylation, isomerization, disproportionation reaction and polymerization processes including Steam Cracking of Naphtha and Natural Gas: To produce C_1 to C_4, olefins, dienes and aromatics. Syngas. There are few textbooks, which provide and cover the abovementioned processes helping in getting various valuable petrochemicals.

Module III includes Selection and Conversion of Petroleum Feedstocks to Petrochemicals: cracking, oxidation, hydrogenation, alkylation, dealkylation, isomerization, disproportionation and polymerization processes including Steam Cracking of Naphtha and Natural Gas: To produce C_1 to C_4, olefins, dienes and aromatics. Syngas.

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This course covers the fundamental issues for the professionals and undergraduate and post graduate students who are interested in learning hydrocarbon chemistry through enough workout examples, exercises, and exercises for self-practices to have a deep understanding on each topic.

Keywords: Petroleum products, Hydrogenation, Alkylation, Dealkylation, Isomerization, disproportionation, Polymerization, Olefins, Dienes, Aromatics, Syngas.

6.0 Course Learning Outcomes

Upon successful completion of this course, students will be able to:

CLO1: Become familiar with the various hydrocarbons and materials found present in the crude oil and their applications through enough workout examples and exercises.
CLO2: Understand chemistry of crude petroleum through workout examples and exercises.
CLO3: Learn properties of hydrocarbons and their characterization through enough workout examples and exercises.
CLO4: Review and discuss various types of crude oils and their processing for refined petroleum products.
CLO5: Have in-depth knowledge of refinery operations and petroleum products through enough examples and exercises.
CLO6: Know petroleum products characterization techniques as per ASTM/IP processes through exercises.
CLO7: Learn about blending of stocks to meet product specifications through various exercises.
CL08: Acquire knowledge of testing and uses of petroleum products through examples and exercises.
CLO9: Become familiar and in-depth understanding with the various processes used in the conversion of materials and hydrocarbons into value added products through enough examples and exercises.

7.0 How the course supports the attainment of the student outcomes

Student Learning Outcomes (1-6)						
1	2	3	4	5	6	7
Moderate	Moderate	Moderate	Low	Moderate	Moderate	

8.0 Course Materials

Online course materials

- Online presentation documents in pdf form
- Audio/visual recording of lectures (Optional)
- Online tutorial and meeting with students upon request

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- Enough MCQs for study and self-practiced MCQs with answers in pdf form in the MLS system
- Reading materials, if any, in pdf form

Textbook and resources (If any)

1. Speight, J. G., *Chemistry and Technology of Petroleum*, 2nd Ed., Dekker, New York, 1991.
2. Speight, J. G., *Petroleum Chemistry and Refining*, Taylor and Francis, New York, 1998.

9.0 Academic Integrity

Students are encouraged to have a look at the NSRIC's statement of academic integrity at NSRIC website. It is noted that by signing this syllabus, you will acknowledge that you have understood that any detected plagiarism should be reported.

10. Assessment for Grade

This course is an academic course (i.e., K12, and university level courses) based on individual and team performance as shown in Table 1. Therefore, the program courses contain many assessments instead of assignments and quizzes for assessment. Student will receive a "Certificate of completion" after successful completion of the course.

Table 1: NSRIC grading system.

Type of Assessment	Grade %
Participation/Engagement/Performance	10%
Assignments	15%
Quizzes	10%
Research Project	20%
Midterm Exam I	15%
Midterm Exam II	15%
Final Exam	15%
Total	**100%**

Important Note:

i) The below-classified courses (i.e., academic courses) will only be evaluated based on the grading system shown in Table 2. A grade and certificate will be issued for the student(s) and participant(s).
A: Advanced level academic level courses; **H**: Higher-level courses (i.e., graduate courses); **I**: Intermediate courses (i.e., university preparatory courses – Grade XII+); **K12**: Foundational, and lower-level courses; **M**: Mid-level courses (i.e., undergraduate courses).

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ii) The below-classified courses will **not** be evaluated based on the grading system shown in Table 2. A certificate will be issued for the student(s) and participant(s).
E: Executive courses; **P**: Professional courses; **S**: Short/seminar courses; **T**: Training courses; **U:** Tutorial Courses; **V:** Vocational training courses; and **W**: Workshop courses.

Participation/Engagement/Performance
Your participation in every aspect of the course is important for the learning process. Your engagement in every discussion in the course, due delivery of all practices will be fruitful. These efforts from your side will reflect your performance in the course delivery and your commitments. This performance is the reflection of your dream grade!!
At the end of the term, below Table 2 will be used for translating your marks into a "Latter Grade" based on the NSRIC grading policy.

Table 2: NSRIC grading system.

Marks	Letter Grade	Points	Description
≥ 93	A+	4.00	Outstanding
≥ 90	A	3.75	
≥ 87	A-	3.50	Excellent
≥ 84	B+	3.25	Very good
≥ 81	B	3.0	
≥ 78	B-	2.75	Moderately Good
≥ 75	C+	2.50	Good
≥ 72	C	2.25	
≥ 69	C-	2.0	Moderately Good
≥ 66	D+	1.75	Pass
≥ 63	D	1.50	
≥ 60	D-	1.25	Poor Pass
< 60	F	0	Failing

11.0 Advice and additional requirements

I advise you to:

- Please contact me, if you need any help.
- Students are expected to attend all scheduled online lectures.
- Students are expected to study from the course materials and/or textbooks, which will help them to study and understand easily.
- Students are encouraged to write their own notes during lectures/presentations (pdf PowerPoint presentations, and additional materials, if any).
- Students are encouraged to attend online platform classes on time because late-attendee disrupts the run of the class for both the instructor and the other students.

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Additional information (During Online Course offering Period)

- The PowerPoint course materials will be available on the NSRIC Platform.
- There will be scheduled discussion/tutorial sessions **every Monday** at the class scheduled time. All students must attend this session (Need student request).
- There will be an office hour for students on Monday from 10:30 am – 11:30 am, Toronto, Canada time. Students need to send an email request so that a Zoom meeting can be arranged. In addition, any time student can set up an online appointment (i.e., phone, zoom, and/or other mode of communication) based on the availability of the course instructor. However, students should send an email request for setting up this type of meeting.

12.0 Course Topics

- **Constituents of Crude Petroleum:** Composition, classification and characterization, Natural gas constituents, Crude oil and gas stabilization. Pre-treatment of crude: Dehydration, desalting and distillation of crude petroleum.
- **Petroleum Analysis and Evaluation:**
- Definitions, ASTM evaluation, Spectroscopic methods, Molecular weight, etc.
- **Metals and Hetero Atoms Presence in Heavy Crude Petroleum:** Hetero atom distribution in refinery distillation cuts, Molecular distillation fractions, SARA separation, Acids-bases-neutrals separations, Structures of hetero atom functions (sulphur, nitrogen, metal compounds, etc.)
- **Asphaltenes and Structure of Petroleum:** Separation, composition, structure studies, molecular weight, molecular models, etc.
- **Physical and Chemical Operations to Produce End Products:** Crude selection for refinery processing: Blending of stocks to meet product specifications. Testing and uses of petroleum products.
- **Selection and Conversion of Petroleum Feedstocks to Petrochemicals:** Cracking, oxidation, hydrogenation, alkylation, dealkylation, isomerization, disproportionation reaction and polymerization processes: Basics.
- **Steam Cracking of Naphtha and Natural Gas:** To produce C_1 to C_4, olefins, dienes and aromatics. Syngas.

Requirements/Instructions

Students are advised to register all Crude Oil Chemistry courses for becoming the master in the subject area.

Bundled Program Description

These bundled courses program is designed for the audiences who are interested to learn in-depth knowledge of crude oil chemistry through enough practices on scientific concepts in the form of workout examples and exercises and question-answer session mode. The course content is designed for

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audiences who are of undergraduate and postgraduate level and refinery personnel responsible for evaluating crude oils in petroleum, oil and gas industry and interested in learning of chemistry of crude oil. This program includes all the basic aspects and in-depth details of contents of petroleum chemistry including crude oil composition, classification and its important characteristics including petroleum analysis and evaluation. The course comprises of processing of petroleum, obtaining of refined petroleum products and further their characterization using ASTM and IP processes. Use of various test methods for evaluation of properties of petroleum products will also be a part of learning of this course.

This program contains three modules (Module I – III). The first module contains 9 lectures, however, second and third module consists of 5 and 6 lectures respectively. Students are strongly advised and encouraged to complete the course titled "Crude Oil Chemistry" by Prof. Dr. A. K. Choubey at NSRIC Platform to understand the designed course content.

13.0 Course Contents and Schedule

No.	Module	Topics	Remarks
Module I			
01	**Constituents of Crude Petroleum**	Composition, classification and characterization,	
02	**Constituents of Crude Petroleum**	Natural gas constituents, Crude oil and gas stabilization	
03	**Constituents of Crude Petroleum**	Pre-treatment of crude: Dehydration, desalting and distillation of crude petroleum	
04	**Petroleum Analysis and Evaluation**	Definitions and ASTM evaluation	1 Assignment 1 Quiz
05	**Petroleum Analysis and Evaluation**	Spectroscopic methods, Molecular weight, etc.	
06	**Metals and Hetero Atoms Presence in Heavy Crude Petroleum**	Hetero atom distribution in refinery distillation cuts, Molecular distillation fractions, SARA separation, Acids-bases-neutrals separations.	
07	**Metals and Hetero Atoms Presence in Heavy Crude Petroleum**	Structures of hetero atom functions (sulphur, nitrogen, metal compounds, etc.)	
Module II			
08	**Asphaltenes and Structure of Petroleum**	Separation, composition, structure studies, molecular weight, molecular models, etc.	

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09	**Physical and Chemical Operations to Produce End Products**	Crude selection for refinery processing: Blending of stocks to meet product specifications.	1 Assignment 1 Quiz
10	**Physical and Chemical Operations to Produce End Products**	Testing and uses of petroleum products.	
Module III			
11	**Selection and Conversion of Petroleum Feedstocks to Petrochemicals**	Cracking, oxidation, hydrogenation, alkylation, dealkylation: Basics	
12	**Selection and Conversion of Petroleum Feedstocks to Petrochemicals**	Isomerization, disproportionation reaction and polymerization processes: Basics	1 Assignment 1 Quiz
13	**Steam Cracking of Naphtha and Natural Gas**	To produce C_1 to C_4, olefins, dienes and aromatics. Syngas.	

Prepared by Prof. Dr. A. K. Choubey, Professor in Chemistry, NSRIC Inc., London, ON, Canada.

Subtitle

The fundamental concepts for beginners and practicing professionals interested in learning Crude Oil Chemistry through enough examples and exercises to have a deep understanding on each topic along with some self-practiced exercises.