SEMESTER – VIII

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 20 (DSE-20)

Transition Metal Clusters-Introduction and Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Transition Metal Clusters- Introduction and Applications (DSE-20)	4	2	--	2	--	--

Learning Objectives:

To introduce the basic concepts of transition metal clusters. To gather a good understanding of the chemistry and various aspects of metal-carbonyl clusters, carboranes, metalloboranes and heteroboranes, metallocarboranes with respect to synthesis, structure and properties.

Learning Outcomes:

On completion of the course, the students will be able to:

- Ensures the students understand the concepts and the properties of transition metal clusters.
- Acquire knowledge of transition metal clusters cluster compounds and explain structure-property, electron counts, and surface analogies of cluster compounds.
- Identify the structure and bonding aspects of transition metal clusters.
- Identify the different types of transition metal clusters reactions and apply the above concepts to explain reactivity of the clusters.
- To study the application of molecular clusters in catalysis.

SYLLABUS OF DSE 20

Unit 1: **(Hours: 12)**

Transition-metal clusters: Low nuclearity metal-carbonyl clusters and 14n+2 rule, high nuclearity metal-carbonyl clusters with internal atoms, polyhedral skeletal electron pair theory (PSEPT), metalloboranes, metallocarboranes.

Unit 2: **(Hours:5)**

Structure, synthesis, bonding aspects and reactivity. Capping rules, metal-ligand complexes vs heteronuclear cluster.

Unit 3: **(Hours: 5)**

Main-group-Transition-metal clusters: Isolobalanalogs of p-block and d-block clusters, limitations,and exceptions.

Unit 4: **(Hours: 8)**

Clusters having interstitial main group elements, cubane clusters and naked or Zintl clusters. Chevrel compounds, infinite metal chains, multidecker molecules-cluster surface analogy. Molecular clusters in catalysis, clusters to materials. Illustrative examples from recent literature.

Practical Component

1. Synthesis of ferrocene and its characterisation using IR, ^{1}H NMR and UV-Visible spectroscopy
2. Synthesis of acetylferrocene and its characterisation using IR, ^{1}H NMR and UV-Visible spectroscopy
3. Synthesis of $[Fe(\eta\text{-}C_5H_5)(\eta\text{-}C_6H_6)]PF_6$ using ligand exchange reaction. Characterisation of the product using IR, ^{1}H NMR and UV-Visible spectrum
4. Estimation of metal ions in the mixture solution- Mg^{2+}- Zn^{2+}, Ca^{2+}- Mg^{2+}, Cu^{2+} - Zn^{2+}titrimetrically.
5. Analysis of given transition metal cluster(metal carbonyls) using various spectroscopic techniques - IR, UV-Visible and mass spectrometry.

Keywords: Transition Metal Clusters, metal-carbonyl clusters, carboranes, metalloboranes, heteroboranes, metallocarboranes, Capping rules, Isolobal relationship, interstitial main group elements, cubane clusters and naked or Zintl clusters, Chevrel compounds, catalysis, clusters to materials, boron-carbides, metal-borides, Synthesis, Reactivity.

Recommended Text Books and References

1. M. P. Mingos and D. J. Wales; Introduction to Cluster Chemistry, Prentice Hall, 1990.
2. N. Greenwood and E. A. Earnshaw; Chemistry of elements, Second Edition, Butterworth-Heinemann, 1997.
3. P. Fehlner, J. F. Halet and J-Y. Saillard; Molecular Clusters: A Bridge to solid-state Chemistry, Cambridge University press, 2007.
4. D. Gupta and A. J. Elias; Basic Organometallic Chemistry: Concepts, Synthesis, and Applications, Universities Press (India), 2010.
5. M. P. Mingos, Essential Trends in Inorganic Chemistry, Oxford, University Press, 1998.

6 C.E. Housecroft, Metal-Metal Bonded Carbonyl Dimers and Clusters, Oxford Chemistry Primers (44), Oxford, University Press, 1996.
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8 F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons, Inc, New York, 1999.
9 G. Wulfsberg, Inorganic Chemistry, Viva Books Pvt Ltd, New Delhi, 2001.
10 B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley & Sons, Inc, New York, 2001.
11 P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Shriver & Atkins Inorganic Chemistry, 4th Edn, Oxford, 2006.
12 J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorgnic Chemistry: Principles of Structures and Reactivity, 4th Edn, Pearson, New Delhi, 2006.
13 R. Xu, W. Pang and Q. Huo (Eds), Modern Inorganic Synthetic Chemistry, Elsevier, New York, 2011.
14 G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd Edn, Pearson, New Delhi, 2009.
15 J. R. Anderson and M. Boudart (Eds), Catalysis: Science and Technology, Springer, London, 2012.
16 P. Powell, Principles of Organometallic Chemistry, 2nd Edn, Chapman and Hall, London, 1988.
17 G. O. Spessard and G. L. Miessler, Organometallic Chemistry, International 2nd Edn, Oxford University Press, Oxford, 2010.
18 D. F. Shriver, H. D. Kaesz and R. D. Adams (Eds), The Chemistry of Metal Cluster Complexes, VCH, New York, 1990.
19 K. J. Klabunde, Free Atoms, Clusters and Nanoscale Particles, Academic Press, New York, 1994.
20 D. M. P. Mingos (Ed.), Structural and Electronic Paradigms in Cluster Chemistry, Springer, Berlin, 1997.
21 P. Braunstein, L. A. Oro and P. R. Raithby (Eds), Metal Clusters in Chemistry, Wiley-VCH, Weinheim, 1999.
22 M. Driess and H. Noth (Eds), Molecular Clusters of the Main Group Elements, Wiley-VCH, Weinheim, 2004.
23 C. E. Housecraft and A. G. Sharpe, Inorganic Chemistry, 3rd Edn, Pearson Education Ltd, Essex, England, 2008.
24 F. Wells, Structural Inorganic Chemistry, 5th Edn, Oxford University Press, Oxford, 1984.