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CROWN ETHERENES: STRUCTURE, PROPERTIES AND MODERN APPLICATIONS

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Abstract

This article studies in detail the chemical nature, structural properties, physicochemical parameters of crown ethers, and the mechanism of their complex formation with metal cations. Crown ethers, as important representatives of supramolecular chemistry, are distinguished by their ion selectivity, transport properties, and catalytic activity. The synthesis, thermodynamic properties, complex stability, and practical applications of crown ethers are extensively analyzed in the work. The principle of their operation is explained visually through diagrams.

Keywords

crown ethers, macrocyclic compounds, complex compounds, selectivity, supramolecular chemistry, ligand, cation, ionic radius, thermodynamics

Introduction: In the second half of the 20th century, a new direction in chemistry was formed - supramolecular chemistry. This direction studies intermolecular interactions. Crown ethers are one of the first and most important discoveries in this field.

Crown ethers were accidentally synthesized by an American scientist in 1967. They have the property of selectively binding metal ions, which makes them very unique.

1. Chemical structure of crown ethers

Crown ethers are closed-ring (macrocycle) compounds consisting of a carbon chain linked by oxygen atoms.

2. General formula:

(−CH2−CH2−O−)n(-CH_2-CH_2-O-)_n(−CH2−CH2−O−)n

Nomenclature:

Example: 18-crown-6 :18 number of atoms in the ring

19 -6 → number of oxygen atoms

18-crown-6 structure.

```
   O
  /   \
CH2     CH2
 |       |
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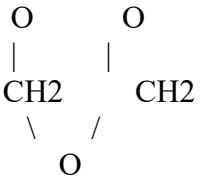

Note:
Oxygen atoms are oriented towards the center

The inner cavity accepts the cation

2. Electronic structure and bonding mechanism

Oxygen atoms in crown ethers:

• sp^3 hybridized

• have 2 lone electron pairs

Therefore, they act as Lewis bases.

Complex formation:

K++18-crown-6→[K(18-crown-6)]+K^+ + 18{-crown-6} [K(180{-crown-6})]+K++18-crown-6→[K(18-crown-6)]+

Complex formation

formationResult:

Ion becomes stable

Dissolves from solvent

3. Thermodynamic properties

Complex formation is characterized by the following quantities:

3.1. Stability constant (K):

K=[ML][M][L]K {[ML]}{[M][L]}K=[M][L][ML]

3.2. Gibbs energy:

ΔG=−RTln⁡K\Delta G = -RT \ln KΔG=−RTlnK

3.3. Influencing factors:

• ionic radius

• solvent type

• temperature

• ring diameter

4. Selectivity mechanism

Crown ethers select ions based on size and energy compatibility.

Compatibility principle

Small ring → small ion (Li+)

Medium ring → Na+

Large ring → K+

Compatibility table:

Crown ether Ion

12-crown-4 -Li^+

15-crown-5 -Na^+

18-crown-6 -K^+

5. Synthesis methods

5.1. Williamson ether synthesis

RO−+R′−X→R−O−R′RO^- + R'-X → R-O-R'RO−+R′−X→R−O−R′

This method produces a long chain and then cyclization is carried out

5.2. Cyclization

• high dilution conditions

• inner ring formation is dominant

Synthesis step

Chain → closure → crown ether

6. Physical properties of crown ethers

• colorless crystals

• soluble in organic solvents

• partially soluble in water

• high boiling point

Areas of application

7.1. Interphase catalysis

Crown ethers transfer ions to the organic phase.

Example:

Na+(water)→organic phase(using crown ether)Na^+(water)→organic phase(using crown ether)Na+(water)→organic phase(using crown ether)

7.2. Analytical chemistry

• in ion selective electrodes

• in the development of sensors

7.3. Biology

• modeling of ion transport through membranes

• artificial ion channels

7.4. Medicine

• drug delivery systems

• used in radiochemistry

7.5. Nano and materials chemistry

• molecular machines

• smart materials

8. Advantages and limitations

Advantages:

• high selectivity

• forms strong complexes

• multifunctional

Disadvantages:

• expensive synthesis

• possible toxicity

• stability problems

9. Modern research

Currently, crown ethers are widely used in:

• nano-sensors

• environmental monitoring

• ion batteries.

Conclusion

Crown ethers are one of the important elements of supramolecular chemistry, and their selective ion binding property is of great importance in science and industry. Their structure and functional capabilities open up broad prospects for the creation of new technologies.

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