

Jahn–Teller Effect and Its Influence on Geometry of Coordination Complexes

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Abstract

The Jahn–Teller effect is an important concept in inorganic chemistry that explains distortions in the geometry of coordination complexes due to uneven occupancy of degenerate orbitals. This effect is particularly observed in transition metal complexes where electronic configurations create instability in symmetric arrangements. As a result, the complex undergoes structural distortion to achieve lower energy and greater stability. The Jahn–Teller effect plays a crucial role in determining bond lengths, coordination geometry, magnetic properties, and spectroscopic behavior of metal complexes. Understanding this phenomenon helps interpret deviations from ideal octahedral or tetrahedral shapes observed experimentally. This article elaborates the influence of the Jahn–Teller effect on the geometry and stability of coordination compounds.

Keywords: Jahn–Teller effect and its influence on geometry of coordination complexes

Introduction

The Jahn–Teller effect and its influence on geometry of coordination complexes arise from the presence of degenerate electronic states in transition metal ions (1). When such degeneracy exists, the system becomes unstable and undergoes distortion to remove degeneracy and lower its overall energy. This distortion results in unequal bond lengths within the complex. The effect is most commonly observed in octahedral complexes of d^9 , high-spin d^4 , and low-spin d^7 configurations (2). In these cases, elongation or compression along one axis occurs, leading to deviation from ideal symmetry. The resulting geometry directly affects ligand interactions and electronic distribution. Spectroscopic studies provide evidence for Jahn–Teller distortions through changes in absorption patterns and splitting of energy levels (3). Magnetic measurements further confirm alterations in electron arrangement due to distortion. Structural characterization using X-ray crystallography reveals differences in bond lengths that validate theoretical predictions. These distortions influence reactivity and stability of coordination complexes. Theoretical explanations based on crystal field and molecular orbital theories describe how removal of degeneracy stabilizes the complex. Thus, the Jahn–Teller effect remains essential for understanding real geometries of coordination compounds. These experimental results validate theoretical predictions based on orbital splitting. Theoretical calculations combined with experimental data

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allow chemists to predict which coordination geometry will be most stable for a given metal–ligand combination (5).

Conclusion

The Jahn–Teller effect provides a fundamental explanation for distortions observed in coordination complexes. By removing orbital degeneracy, the system achieves greater stability through structural changes. This effect influences bond lengths, geometry, and electronic properties. Understanding Jahn–Teller distortions allows chemists to interpret deviations from ideal shapes and predict behavior of transition metal complexes. The integration of theoretical models with experimental observations ensures its continued relevance in inorganic chemistry.

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