Al-Quds University

Deanship of Graduate Studies

Prediction of keto/enol tautomerism using computational methods

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M.Sc. Thesis

Jerusalem-Palestine

1441/2019

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This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Pharmaceutical Sciences at Deanship of Graduate Studies in Al-Quds University in Jerusalem, Palestine.

1441/2019

Al-Quds University

Deanship of Graduate Studies

Pharmaceutical Sciences Programme

Thesis Approval

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Master Thesis Submitted and Accepted on 22/12/2019

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Jerusalem, Palestine

1441/2019

Dedication

This thesis is dedicated to my parents, without whose support and aid, in easy and rough, this accomplishment would never have been possible.

This thesis is dedicated to my brother and sister, siblings and friends, may their lives be prosperous and may their achievements echo.

This thesis is dedicated to my grandmother, a second mother, and to the soul of my grandfather, both from whom my requests were never faced with a no.

This thesis is dedicated to what has been, what is being, what could have been, and what is to come.

Declaration

I certify that this thesis is submitted for the degree of master, is the result of my own research, except where otherwise acknowledged, and that this study has not been submitted for a higher degree to any other university or institution.

Signed: 

Anas Omar Yusuf Najjar

Date: 22/12/2019

Acknowledgements

In the Name of Allah, the Most Gracious, the Most Merciful, was this thesis started, and in His Name was it ended. To Allah is my utmost gratitude, His guidance and choosing affects my life and my work. I humbly acknowledge everything He has provided me and everything He wisely took.

Special gratitude is to my supervisor, Professor Dr Rafik Karaman, for his continued support and aid in preparing this work, for his efforts as a mentor, and for his guidance in my research.

Special gratitude is to Dr Salih Al-Jabour, for his lengthy discussions on quantum chemistry with me and for his aid and support in preparing this work.

I am deeply grateful for the Dean of my College, Dr rer. med. Ahmad Amro, who showed me how a teacher can be a friend, and how a friend can be a brother, and how this trinity can aid in life, work, research, and the future.

I am thankful for the Pharmacy Research Team, who have been a second family at times, and a duty at others. Regards and thanks are to Beesan Warasna, Muhannad Al-Qiq, Abrar Jamous, and Maryam Sawalha, all being brothers and sisters in arms in the face of the unknown.

Abstract

The measurement of keto/enol tautomerism ratios is a challenging endeavour which has had many different methods throughout history starting from bromine titration and leading to computational methods today. However, there is a vastly large amount of computational methods to choose from, and no real idea as to which method is the best for finding the keto/enol tautomerism ratios. This study applied the use of seven of the most commonly used functionals by researchers on 52 compounds to find the optimal functional, basis set, and solvation cavity for keto/enol tautomerism. However, many of the results obtained from the literature are for neat solutions and, hence, cannot be solvated and were compared to gas phase results. The results obtained showed that the best of the most commonly applied functionals is B3LYP used in tandem with 6-31G basis set and for solvation the Bondi cavity proved to be the most accurate. There is still further research to be conducted as to compare this functional and its basis set combination with other newer functionals that are not very common.

قياس نسبة الكيتون إلى الإينول باستخدام الأساليب المحوسبة

إشراف الأستاذ الدكتور رفيق قرمان

إعداد الطالب: أنس عمر يوسف النجار

الملخص

تعتبر عملية قياس نسبة الكيتون إلى الإينول لخليط متجانس لنفس المادة عملية صعبة الأمر الذي دعا بدوره إلى تطوير العديد من المنهجيات والتجارب على مر التاريخ بداية بالمعايرة الكيميائية بمساعدة البروم وانتهاءاً بالأساليب المحوسبة بمساعدة برامج الكيمياء الكمية. لكن، وبالرغم من توفر عدد كبير من الخيارات المتاحة لقياس النسب بمساعدة الحاسوب، إلا أن تحديد الأسلوب الأمثل يشكل معضلة أمام الباحث.

تبحث هذه الدراسة إمكانية تطبيق الأساليب السبعة الأكثر إنتشاراً في حسابات الكيمياء الكمية في تحديد نسبة الكيتون إلى الإينول وذلك إستعانةً ب52 مركباً سبق وتم تحديد ونشر نسب مكوناتها مخبرياً ومقارنتها بنتائج الحساب الكمي لهذه الدراسة. كما وتبحث إمكانية تحديد "فجوة المحلول النظرية" الأمثل. لكن من الجدير ذكر أن العديد من المركبات التي تم نشر نسبها سابقاً كانت نقية وليست ضمن نظام محلول، مما دعا الباحث إلى الاكتفاء بمقارنة الحسابات الكمية للحالة الغازية للمركب مع النسب المنشورة.

توصل البحث إلى كون أسلوب الحساب الكمي (بي 3 لِب –B3LYP) هو الأمثل في تحديد نسبة الكيتون إلى الإينول وخاصة عند توظيف هذا الأسلوب في إطار مجموعة (31-6 جي – 6-31G). كما وتوصل البحث إلى كون (بوندي – Bondi) فجوة المحلول النظرية الأمثل.

تكمن بالرغم من هذه النتائج حاجة إلى مقارنة المزيد من الأساليب الكمية مع النتائج العملية والنظرية للتوصل إلى المنهجية المثلى في تحديد نسب الكيتون والإينول بصورة قابلة للتطبيق على نطاق أوسع.

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List of Abbreviations

Abbreviation	Meaning
NMR	Nuclear magnetic resonance
H	Enthalpy
S	Entropy
T	Temperature
G	Gibbs free energy
K_T	Tautomerism equilibrium constant
SCF	Self-consistent field
LCAO	Linear combination of atomic orbitals approximation
DFT	Density functional theory