

Avoiding Plagiarism in the Era of Generative AI

Tirayut Vilaivan

*Department of Chemistry
Faculty of Science
Chulalongkorn University*

Ethical obligations of authors

“An author’s central obligation is to **present an accurate and complete account of the research performed**, absolutely avoiding deception, including the data collected or used, as well as an objective discussion of the significance of the research..”

“An author **should identify the source of all information quoted or offered**, except that which is common knowledge. **Information obtained privately**, as in conversation, correspondence, or discussion with third parties, **should not be used or reported in the author’s work without explicit permission** from the investigator with whom the information originated.”

“The co-authors of a paper should be all those persons who have **made significant scientific contributions** to the work reported and who **share responsibility and accountability** for the results.

จริยธรรมและจรรยาบรรณทางวิชาการ

ในการพิจารณากำหนดตำแหน่งวิชาการต้องคำนึงถึงจริยธรรมและจรรยาบรรณทางวิชาการ ดังนี้

- (๑) ต้องมีความซื่อสัตย์ทางวิชาการ ไม่นำผลงานของผู้อื่นมาเป็น ผลงานของตน และไม่ลอกเลียนผลงานของผู้อื่น ไม่นำผลงานของตนเองในเรื่องเดียวกันไปเผยแพร่ในวารสารวิชาการมากกว่าหนึ่งฉบับ รวมถึงไม่คัดลอกข้อความใด ๆ จากผลงานเดิมของตน โดยไม่อ้างอิงผลงานเดิม ตามหลักวิชาการ ทั้งนี้ ในลักษณะที่จะทำให้เข้าใจผิดว่าเป็นผลงานใหม่
- (๒) ต้องอ้างอิงบุคคลหรือแหล่งที่มาของข้อมูลที่นำมาใช้ ในผลงานทางวิชาการของตนเองเพื่อแสดงหลักฐานของการค้นคว้า
- (๓) ต้องไม่คำนึงถึงผลประโยชน์ทางวิชาการจนละเลยหรือ ละเมิดสิทธิส่วนบุคคลของผู้อื่นหรือสิทธิมนุษยชน
- (๔) ผลงานทางวิชาการต้องได้มาจากการศึกษาโดยใช้หลักวิชาการ เป็นเกณฑ์ ปราศจากอคติ และเสนอผลงานตามความเป็นจริง ไม่จงใจเบี่ยงเบนผลการศึกษาหรือวิจัย โดยหวังผลประโยชน์ส่วนตัว หรือเพื่อก่อให้เกิดความเสียหายแก่ผู้อื่น และเสนอผลงานตามความเป็นจริง ไม่ขยายข้อค้นพบ โดยปราศจากการตรวจสอบยืนยันในทางวิชาการ
- (๕) ต้องนำผลงานไปใช้ประโยชน์ในทางที่ชอบธรรมและชอบด้วยกฎหมาย
- (๖) หากผลงานทางวิชาการมีการใช้ข้อมูลจากการทำการวิจัย ในคนหรือสัตว์ ผู้ขอตำแหน่งจะต้องยื่นหลักฐานแสดงการอนุญาตจากคณะกรรมการจริยธรรมการวิจัย ของโรงเรียนนายร้อยตำรวจที่มีการดำเนินการ

จริยธรรมและจรรยาบรรณทางวิชาการ

๕. การจัดทำวิทยานิพนธ์ฉบับสมบูรณ์

๕.๑ การจัดทำวิทยานิพนธ์

การจัดทำวิทยานิพนธ์ ถือเป็นเงื่อนไขหนึ่งของการสำเร็จการศึกษาสำหรับการศึกษาในหลักสูตรที่มีวิทยานิพนธ์เป็นส่วนหนึ่งของการศึกษา ทั้งนี้ในการจัดทำวิทยานิพนธ์ นิสิตจะต้องตระหนักถึงความสำคัญของการคัดลอกผลงานวิชาการของผู้อื่นมาเป็นของตนเองโดยไม่มีการอ้างอิงแหล่งที่มาของข้อมูล การกระทำดังกล่าวถือเป็นความผิดทางวิชาการที่ก่อให้เกิดความเสียหายต่อสถาบัน มีผลกระทบต่อคุณภาพและจริยธรรมทางวิชาการและมีบทลงโทษ ซึ่งนิสิตสามารถศึกษารายละเอียดในเรื่องนี้ได้ที่ <http://www.grad.chula.ac.th/download/files/Plagiarism.pdf>

นอกจากนี้การจัดพิมพ์รูปแบบวิทยานิพนธ์ ก็เป็นอีกเรื่องหนึ่งของการทำวิทยานิพนธ์ที่นิสิตจะต้องให้ความสำคัญ เนื่องจากในข้อบังคับจุฬาลงกรณ์มหาวิทยาลัย ว่าด้วยการศึกษาในระดับบัณฑิตศึกษา พ.ศ. ๒๕๕๑ ข้อ ๑๐๑ ได้กำหนดไว้ว่า “รูปแบบการพิมพ์วิทยานิพนธ์ให้เป็นไปตามคู่มือการพิมพ์วิทยานิพนธ์ที่บัณฑิตวิทยาลัยกำหนด” ซึ่งบัณฑิตวิทยาลัยได้จัดทำคู่มือการพิมพ์วิทยานิพนธ์ และ Template ต้นแบบในการพิมพ์วิทยานิพนธ์ เพื่ออำนวยความสะดวกแก่นิสิตบัณฑิตศึกษา ในการพิมพ์วิทยานิพนธ์ฉบับสมบูรณ์ ลดข้อผิดพลาดในการพิมพ์ และสามารถพิมพ์วิทยานิพนธ์ได้ถูกต้องตามมาตรฐานการพิมพ์วิทยานิพนธ์ที่นิยมใช้กันทั่วไป โดยนิสิตสามารถ Download คู่มือการพิมพ์วิทยานิพนธ์และ Template ต้นแบบในการพิมพ์วิทยานิพนธ์ได้ที่ <http://www.grad.chula.ac.th/thesis/download.php>

An excerpt from a thesis

Gallic acid is one major components of phenolic compounds, also known as 3,4,5-trihydroxybenzoic acid, found in gallnuts, sumac, witch hazel, tea leaves, oak bark, and other plants. The chemical formula is $C_6H_2(OH)_3COOH$ (Figure 2.10). Gallic acid is found both free and as part of tannins. Salts and esters of gallic acid are termed gallates. Despite its name, it does not contain gallium.

Gallic acid is commonly used in the pharmaceutical industry. It is used as a standard for determining the phenol content of various analytes by the Folin-Ciocalteu assay; results are reported in gallic acid equivalents. Gallic acid can also be used as a starting material in the synthesis of the psychedelic alkaloid mescaline. Gallic acid seems to have anti-fungal and anti-viral properties. It acts as an antioxidant and helps to protect our cells against oxidative damage. Gallic acid was found to show cytotoxicity against cancer cells, without harming healthy cells. It is used as a remote astringent in cases of internal haemorrhage as well as is also used to treat albuminuria and diabetes. Some ointments to treat psoriasis and external haemorrhoids contain gallic acid.

en.wikipedia.org/wiki/Gallic_acid

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Gallic acid

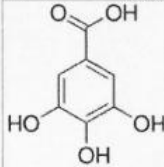

From Wikipedia, the free encyclopedia

Gallic acid is a trihydroxybenzoic acid, a type of phenolic acid, a type of organic acid, also known as 3,4,5-trihydroxybenzoic acid, found in gallnuts, sumac, witch hazel, tea leaves, oak bark, and other plants.^[1] The chemical formula is $C_6H_2(OH)_3COOH$. Gallic acid is found both free and as part of hydrolyzable tannins.

Salts and esters of gallic acid are termed 'gallates'. Despite its name, it does not contain gallium.

Gallic acid is commonly used in the pharmaceutical industry.^[2] It is used as a standard for determining the phenol content of various analytes by the Folin-Ciocalteu assay; results are reported in gallic acid equivalents.^[3] Gallic acid can also be used as a starting material in the synthesis of the psychedelic alkaloid mescaline.^[4]

Gallic acid seems to have anti-fungal and anti-viral properties. Gallic acid acts as an antioxidant and helps to protect human cells against oxidative damage. Gallic acid was found to show cytotoxicity against cancer cells, without harming healthy cells. Gallic acid is used as a remote astringent in cases of internal haemorrhage. Gallic acid is also used to treat albuminuria and diabetes. Some ointments to treat psoriasis and external haemorrhoids contain gallic acid.^[5]

Gallic acid	
	
IUPAC name	[hide]
3,4,5-trihydroxybenzoic acid	
Other names	[hide]

ครั้งแรกในประวัติศาสตร์ สภาจุฬา ถอนปริญญาเอก

วิทยานิพนธ์เรื่อง [REDACTED] ของ [REDACTED] ซึ่งเป็นวิทยานิพนธ์ที่ใช้เป็นส่วนหนึ่งของการสำเร็จการศึกษา ได้คัดลอกจากเอกสารหรือผลงานทางวิชาการอื่นกล่าวคือ ในจำนวนวิทยานิพนธ์ทั้งหมด 205 หน้า ได้คัดลอกจากเอกสารหรือผลงานทางวิชาการอื่นเป็นจำนวน 4,019 บรรทัด 122 ตาราง และ 53 รูป คิดเป็นจำนวนมากกว่าร้อยละ 80 ของวิทยานิพนธ์ทั้งหมด

กรณีนี้ข้อเท็จจริงปรากฏแล้วว่า เนื้อหาวิทยานิพนธ์ฉบับนี้ได้มีการคัดลอกมาจากงานวิชาการอื่นในปริมาณที่มากอย่างมีนัยสำคัญและในส่วนที่เป็นสาระสำคัญ ซึ่งข้อ 8.3 แห่งระเบียบจุฬาลงกรณ์มหาวิทยาลัยว่าด้วยการศึกษาาระดับบัณฑิตศึกษา พ.ศ.2542 กำหนดไว้ชัดเจนว่า “หลักสูตรในชั้นดุุษฎีบัณฑิตเน้นการวิจัยโดยการทำให้วิทยานิพนธ์ที่ก่อให้เกิดความรู้ใหม่และมีคุณภาพสูงในทางวิชาการ” วิทยานิพนธ์จึงต้องก่อให้เกิดความรู้ใหม่และมีคุณภาพทางวิชาการ ซึ่งคณะกรรมการบริหารหลักสูตร คณะกรรมการบริหารคณะ รวมทั้งคณะกรรมการบริหารบัณฑิตวิทยาลัยเห็นตรงกันว่าวิทยานิพนธ์ฉบับนี้ไม่ได้คุณภาพและมาตรฐานทางวิชาการ ดังนั้น เมื่อองค์ความรู้ที่เสนอในวิทยานิพนธ์ปรากฏอยู่ในผลงานวิจัยของ [REDACTED] จำกัด ที่เสนอต่อ [REDACTED] แล้ว องค์ความรู้ดังกล่าวที่เสนออยู่ในวิทยานิพนธ์จึงไม่ใช่องค์ความรู้ใหม่ อันเป็นเงื่อนไขสำคัญของการสำเร็จการศึกษาในระดับดุุษฎีบัณฑิต นอกจากนั้นการที่วิทยานิพนธ์ฉบับนี้ไปคัดลอกผลงานวิจัยของ [REDACTED] มาแบบคำต่อคำ โดยไม่ได้มีการวิเคราะห์ วิจัย หรือทำสิ่งใดที่แตกต่างหรือสร้างองค์ความรู้อื่นขึ้นมา ก็เป็นการคัดลอกงานวิชาการอื่นซึ่งถือว่าเป็นการกระทำที่ผิดจริยธรรมทางวิชาการอย่างร้ายแรง

สภาจุฬาลงกรณ์มหาวิทยาลัยในการประชุมครั้งที่ 746 เมื่อวันที่ 21 มิถุนายน 2555 จึงมีมติให้เพิกถอนมติสภามหาวิทยาลัยครั้งที่ 699 เมื่อวันที่ 22 พฤษภาคม 2551 ที่ได้อนุมัติปริญญาดุุษฎีบัณฑิต สาขาวิชาเทคโนโลยีการเกษตรให้แก่ [REDACTED] ทั้งนี้ ตั้งแต่วันที่ 21 มิถุนายน 2555 เป็นต้นไป

To plagiarize means...

- to steal and pass off (the ideas or words of another) as one's own
- to use (another's production) without crediting the source
- to commit literary theft
- to present as new and original an idea or product derived from an existing source

Examples of plagiarism

- turning in someone else's work as your own
- copying words or ideas from someone else without giving credit
- failing to put a quotation in quotation marks
- giving incorrect information about the source of a quotation
- changing words but copying the sentence structure of a source without giving credit
- copying so many words or ideas from a source that it makes up the majority of your work, whether you give credit or not

Giving a citation alone is *not* sufficient to prevent plagiarism.

The Exception: Common Knowledge

- Common knowledge is information generally known.
- Widely known scientific and historical facts can be used without citation and without fear of committing plagiarism.
- Ideas or interpretations are usually not considered common knowledge, unless they are very widely held.
- Verbatim language drawn from a source is rarely common knowledge, unless the formulation is widely known.
- It is always better to cite a source if you're not sure whether the information or idea is common knowledge.

Self-plagiarism

- Publishing the same text/data/picture from your own works in more than one publication is considered **self-plagiarism**.
- Exceptions include the publication of a full paper following a conference abstract or proceedings, corrigenda, translations, and review articles.
- In all cases, citation, paraphrasing/ quotation and/or copyright notice must still be applied.
- A **preprint** is a preliminary version of a publication. Therefore, the publication of a paper with essentially duplicate content from the preprint is acceptable, as long as they are cross-referenced to each other.

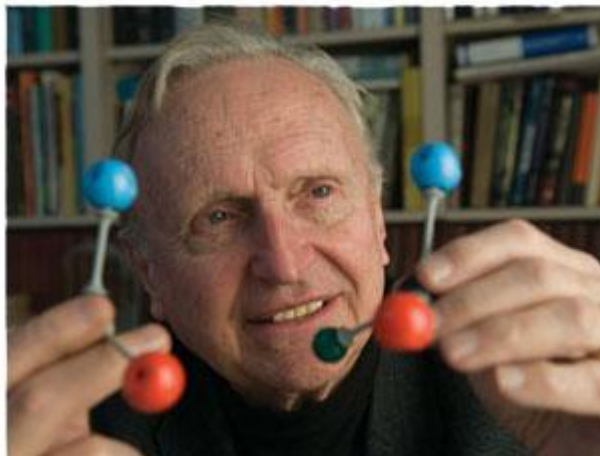
What's wrong with self plagiarism?

- Inappropriate use of resources
- Creating false impression on authors' productivity
- Distortion of literature (same set of data, but reported as if they are new)
- Copyright violation

“Self-plagiarism comes down to the central issue of deception; were the authors trying to deceive the editors, the referees, and the readers into presenting recycled data, text, and figures as entirely new material?”

“..if the paper is presenting new and exciting data and conclusions, ..., then this introductory scheme should also be novel and distinct from previously published work..”

Eminent chemist denies self-plagiarism in 'space dinosaurs' paper



"When I submitted it I made it clear what I had done to avoid personal plagiarism while still meeting the purpose of the Perspective; it would have made no sense not to describe the previous work, which was requested, as long as I gave the appropriate references,"

Ronald Breslow
Columbia University

http://giving.columbia.edu/giftnews/campaigninsert_chemistry.html

Extract from 'Evidence for the Likely Origin of Homochirality in Amino Acids, Sugars, and Nucleosides on Prebiotic Earth' (*J. Am. Chem. Soc.* **134**, 6887–6892; 2012). (now retracted)

Extract from 'The origin of homochirality in amino acids and sugars on prebiotic earth' (*Tetrahedron Lett.* **52**, 4228–4232; 2011).

shown³² (cf. refs 33 and 34 for related work), and then use those sugars to catalyze the formation of the normal proteinogenic L-amino acids. Good credibly prebiotic examples of the latter process have not yet been produced.

acids to catalyze the formation of some D sugars, as Pizzarello and Weber have shown,²⁷ and then use those sugars to catalyze the formation of the normal L amino acids. Good credibly prebiotic examples of the latter process have not yet been produced.

Further work is needed to show prebiotic versions of the conversion of D-glyceraldehyde to D-ribose, D-glucose, D-fructose, and D-2-deoxyribose—such efforts are underway in our laboratory. We also need a credible way in which nucleosides and nucleotides could be formed from these sugars and pyrimidines, not just purines. Finally, of course, we all need ways in which these and other sensible building blocks could assemble into structures with the exciting properties of life.

Further work is needed to show credibly prebiotic versions of the conversion of D-glyceraldehyde to D-ribose, D-glucose, D-fructose, and D-2-deoxyribose, efforts underway in our lab. We also need a credible way in which nucleosides and nucleotides could be formed from these sugars and other components. Finally, of course, we all need ways in which these and other sensible building blocks could assemble into structures with the exciting properties of life. An implication from this work is that elsewhere in the

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Avoiding Plagiarism: Quoting

When the words of an expert, authority, or relevant individual are particularly clear or expressive, you may want to quote them. Do **not** quote all the time: save quotes for instances where the wording is especially powerful.

When should I quote?

- When language is particularly vivid or expressive.
 - When exact wording is needed for technical accuracy.
 - When the words of an important authority lend weight to an argument.
-

How do I show I am quoting?

- Name the source in an introductory phrase.
- Use quotation marks or indent long quotations.
- Cite the source appropriately.

If you fail to do this, it is **plagiarism**.

Original source

Because of their unique perspective, Americans fear globalization less than anyone else, and as a consequence they think about it less than anyone else. When Americans do think about globalization, they think of the global economy as an enlarged version of the American economy.

Thurow, L. (1993).
Fortune Favors the Bold (p. 6).
New York: Harper Collins.

Avoiding Plagiarism: Quoting

Accurate quoting

Lester Thurow (1993) asserts that the American reaction to globalization is different from that of the rest of the world in that “Americans fear globalization less than anyone else, and as a consequence . . . think about it less than anyone else” (p. 6).

Why is this accurate?

The writer has introduced the quotation with his/her own words and has indicated where exact words of the source begin and end. S/he has also named the source in an introductory phrase.

(Complete Thurow reference appears in bibliography)

Plagiarism

The American view of globalization is unlike that of the rest of the world. **Because of their unique perspective, Americans fear globalization less than anyone else, and therefore think about it less than anyone else** (Thurow, 1993).

Why is this plagiarism?

Although the writer has identified the source, s/he has **not** put quotation marks around his words, thereby allowing the reader to think the words are the writer’s, not Thurow’s.

Avoiding Plagiarism: Paraphrasing

Exactly what does “paraphrase” mean?

It means taking the words of another source and restating them, using your own vocabulary.

In this way, you keep the meaning of the original text, but do not copy its exact wording.

For the benefit of students who may not have had practice paraphrasing from sources, the following guidelines may be useful.

What strategies can I use to paraphrase?

- **Use synonyms** for all words that are not generic.
Terms like *people*, *world*, or *food* are so common that it is often difficult to find a synonym.

- **Change the structure** of the sentence.

- **Change the voice** from active to passive and vice versa.

- **Reduce clauses** to phrases.

- **Change parts of speech.**

- **Cite your source.**

Because of their unique perspective, Americans fear globalization less than anyone else, and as a consequence they think about it less than anyone else. When Americans do think about globalization, they think of the global economy as an enlarged version of the American economy.

Thurow, L. (1993). *Fortune Favors the Bold* (p. 6). New York: Harper Collins.

Avoiding Plagiarism: Paraphrasing

According to Lester Thurow (1993), Americans **fear globalization less** than people from other countries and **as a consequence** spend less time **thinking about it**. Indeed, Americans see globalization **as an enlarged version of** their own economy.

Why is this plagiarism?

The writer has used Thurow's exact words without enclosing them in quotation marks. S/he has only substituted synonyms here and there. Even though Thurow is credited with a citation, this would be considered **plagiarism**.

Lester Thurow (1993) maintains that because Americans see globalization simply as a bigger form of their own economy, they are less concerned about it than is the rest of the world.

Why is this acceptable?

The writer has kept the meaning of the original passage without copying words or structure. Words like *globalization* and *Americans* are generic terms (i.e., terms that are commonly used for the concept they illustrate – it is difficult to find synonyms for them). Thus you may use these words without placing them in quotation marks.

Plausible plagiarism in AI-generated contents

LLMs are trained to generate text by digesting vast amounts of previously published writing. As a result, **their use could result in something akin to plagiarism** — if a researcher passes off the work of a machine as their own, for instance, or if a machine generates text that is very close to a person’s work without attributing the source. The tools can also be used to disguise deliberately plagiarized text, and any use of them is hard to spot.

Nature News, 30 Jul 2024

TORTURED PHRASES FOUND IN COMPUTER-SCIENCE PAPERS

Scientific term	Tortured phrase
Big data	Colossal information
Artificial intelligence	Counterfeit consciousness
Deep neural network	Profound neural organization
Remaining energy	Leftover vitality
Cloud computing	Haze figuring
Signal to noise	Flag to commotion
Random value	Irregular esteem

In April 2021, a series of strange phrases in journal articles piqued the interest of a group of computer scientists. The researchers could not understand why authors would use the terms ‘counterfeit consciousness’, ‘profound neural organization’ and ‘colossal information’ in place of the more widely recognized terms ‘artificial intelligence’, ‘deep neural network’ and ‘big data’. Further investigation revealed that these strange terms — which the researchers dub “tortured phrases” — are probably the result of automated translation or software that attempts to disguise plagiarism.


Nature News, 05 Aug 2021

Cabanac, G. et al. (2021) <https://doi.org/10.48550/arXiv.2107.06751>.

Fabricated and inaccurate referencing by AI

Model: Default (GPT-3.5)

L Write a short paper intended for a general audience that summarizes prevention strategies within the field of dermatology. Include at least 3 references to papers that are indexed in Medline. Provide in-text citations and a complete reference list, including the PMID number for each.

 Dermatology is the branch of medicine that deals with the diagnosis and treatment of skin, hair, and nail disorders. Skin disorders, in particular, are highly prevalent, and their incidence is increasing worldwide. Therefore, preventing skin disorders is crucial to maintaining skin health and preventing associated complications. This paper will summarize some of the prevention strategies within the field of dermatology.

Sun protection is one of the most important prevention strategies in dermatology. Prolonged sun exposure is the primary cause of skin cancer and skin aging. Therefore, using sunscreens, wearing protective clothing, and avoiding the sun during peak hours are essential in preventing skin damage. A study by Chen et al. (2021) found that sunscreen use significantly reduced the incidence of melanoma and squamous cell carcinoma, indicating the importance of sun protection.

Another important prevention strategy is early detection and treatment of skin disorders. Regular skin exams by a dermatologist can help detect and treat skin cancer and other skin disorders early. In a study by Telfer et al. (2009), regular skin exams led to the detection of more skin cancers at earlier stages, resulting in better treatment outcomes.

Maintaining a healthy lifestyle is also critical in preventing skin disorders. A balanced diet rich in vitamins and minerals, regular exercise, and stress management can help prevent skin aging and reduce the risk of skin cancer. A study by Kwon et al. (2015) found that a healthy lifestyle, including a balanced diet and regular exercise, was associated with a reduced risk of skin aging in middle-aged women.

In conclusion, prevention strategies in dermatology are crucial in maintaining skin health and preventing associated complications. Sun protection, early detection and treatment of skin disorders, and maintaining a healthy lifestyle are some of the key prevention strategies. By following these strategies, we can protect our skin and maintain its health.

References:

- Chen, A. C., Martin, A. J., Choy, B., Fernandez-Penas, P., & Dalziel, R. A. (2021). A systematic review of the relationship between sunscreen use and the prevention of melanoma and non-melanoma skin cancer. *European Journal of Dermatology*, 31(1), 1-9. PMID: 33635047
- Kwon, H. H., Yoon, J. Y., Park, S. Y., Min, S., Suh, D. H., & Kim, J. H. (2015). A comprehensive study on the association between diet and skin aging in Korean women. *Journal of the American Academy of Dermatology*, 73(2), 242-250. PMID: 26183923
- Telfer, N. R., Colver, G. B., Morton, C. A., & British Association of Dermatologists Therapy Guidelines and Audit Subcommittee. (2009). Guidelines for the management of basal cell carcinoma. *British Journal of Dermatology*, 161(4), 643-659. PMID: 19663808

Chen et al. and Kwon et al. are fabricated references. The Telfer et al. reference has correctly listed authors, title, and journal, but the year, volume, page numbers, and PMID number are inaccurate. Ultimately, this output produced no references deemed authentic and accurate.

“The likelihood of fabricated references significantly differed based on prompt variations; yet the frequency of authentic and accurate references remained low in all cases.”

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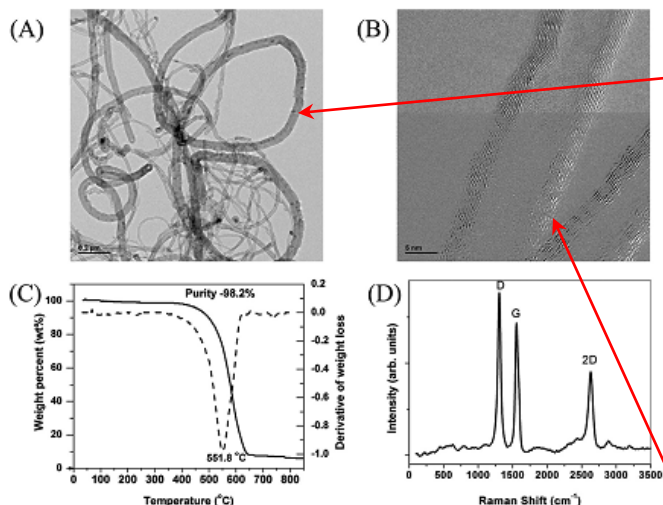


Figure 1. (A) Low- and (B) high-resolution TEM images of the CNTs obtained over Fe–Co/CaCO₃ catalyst, the weight loss profile and the oxidation rate of the CNTs (C), and their corresponding Raman scattering spectra (D).

energy, by taking advantage of the enhancement in the biomass of the plants when they are exposed to nanosized materials and fertilizers.

RESULTS AND DISCUSSION

Carbon Nanotube Analysis. The multiwall carbon nanotubes (CNTs) used in this study were produced on an Fe–Co/CaCO₃ catalyst with a Fe/Co/CaCO₃ weight ratio of 2.5:2.5:95 using acetylene as carbon source at 720 °C. The yield was found to be around 80%. The low- and high-magnification TEM images of CNTs are shown in panels A and B of Figure 1, respectively. Thermogravimetric analysis (TGA) was performed to characterize the purity of the purified CNTs in an airflow rate of 150 mL/min. The first derivative of the TGA curve determines the decomposition temperature of the sample. Figure 1C shows the weight loss profile of the purified nanotubes, which were heated from 25 to 850 °C at a rate of 5 °C/min. The normalized TGA curve and its first derivative indicate a significant mass drop at around 551 °C, which corresponds to the weight loss due to the combustion of the CNTs. The quantitative analysis revealed that, after the single-step purification in HCl, the purity of the CNT product was higher than 98%. Raman spectroscopy has been widely used to analyze the crystallinity and the diameter distribution of CNTs. The Raman scattering spectrum of the CNTs grown on Fe–Co/CaCO₃ is shown in Figure 1D. The characteristic bands for CNTs are the D band, G band, and the 2D

band. The D band is present between 1305 and 1330 cm⁻¹ and is related to the presence of defects and impurities in the carbon nanotube. The G band, present between 1500 and 1605 cm⁻¹, is also known as the tangential band and arises from the E_{2g} mode of the graphite plane. The G band position is relatively constant for CNT material excited at different energies.^{18–20} The last important mode observed in the Raman spectrum of CNTs is the 2D band or the second-order harmonic of the D band, which is often present between 2450 and 2650 cm⁻¹. The 2D band is also highly dispersive and associated with the degree of CNT crystallinity. The relative intensities between the G and the D band (*I_G/I_D*) and between the 2D and G band (*I_{2D}/I_G*) are found to be 0.81 and 0.63, respectively. These values indicate an interplanar distance of 0.342 nm between the graphite layers, as shown by Yoshida *et al.*²¹

Carbon Nanotubes Affect the Germination Rate. To test whether the synthesized carbon nanotubes could affect germination and development of crop seedlings, we placed sterile tomato seeds (*cv.* Micro-Tom) on standard agar Murashige and Skoog medium (MS medium) supplemented with different concentrations of CNTs (10, 20, 40 µg/mL). The MS medium without CNTs was used for control experiments. As shown in Figure 2A,B, addition of carbon nanotubes to agar medium was found to accelerate the process of seed germination and significantly shortened the germination time. Tomato seeds placed on medium with CNTs (10, 20, 40

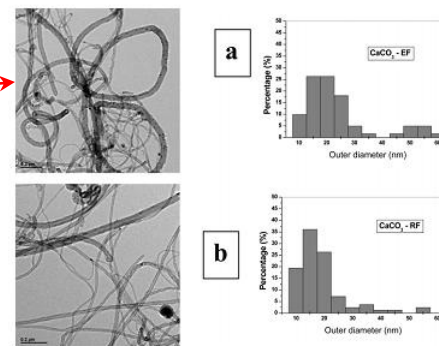


Figure 2. Low-magnification TEM images and statistical analysis illustrating the diameter distributions of the nanotubes synthesized by both EF and RF *c*VCD methods.

with the help of a confocal Raman microscope (high stability BX41) equipped with Olympus objectives (100×, 50×, and 10×). The laser spot diameter was about 1 µm. A Peltier CCD camera detection system was employed for the data acquisition. The spectral resolution was 1 cm⁻¹.

(*c*) TGA/DSC. Thermogravimetric analysis (TGA Mettler Toledo 815e) was also performed as part of the structural

injection. Acetylene elutes at approximately 5 min under these conditions and is the major peak observed in the chromatograms.

2.6. Effluent Gas Analysis for Total Hydrocarbons by GC/FID. Light hydrocarbons (C₁ to C₄) along with the total effluent hydrocarbon profiles were determined using the same Varian 3600 GC/FID system as described above. For these analyses, 50 µL of sample gas was injected. At the time of injection, the

Morphology of Multiwalled Carbon Nanotubes

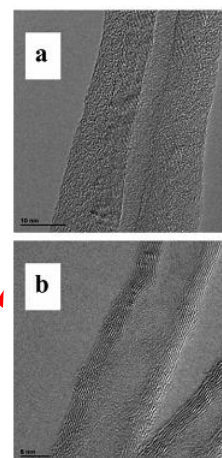


Figure 3. High-resolution TEM images of nanotubes produced by two different methods (a) EF and (b) RF after 50 min of growth reaction. The nanotubes produced by EF appear to be coated by a layer of amorphous carbon which is not apparent on those grown in RF.

with aspect ratios on the order of hundreds. Another interesting observation is that the number of walls on the nanotubes varied with the heating method. The nanotubes produced by RF exhibited 7–12 carbon layers with outer/inner diameter (OD/ID) ratios ranging between 2.0 and 2.5. The nanotubes grown

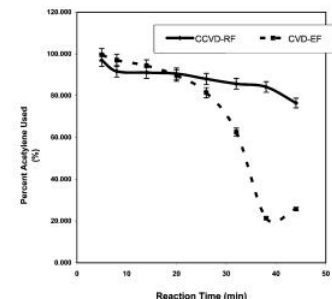


Figure 4. Amount of acetylene consumed during the growth reaction as a function of reaction time for the two different heating methods.

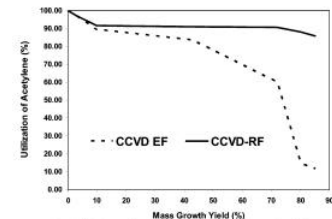


Figure 5. Utilization of acetylene versus the mass growth efficiency for two different heating methods.

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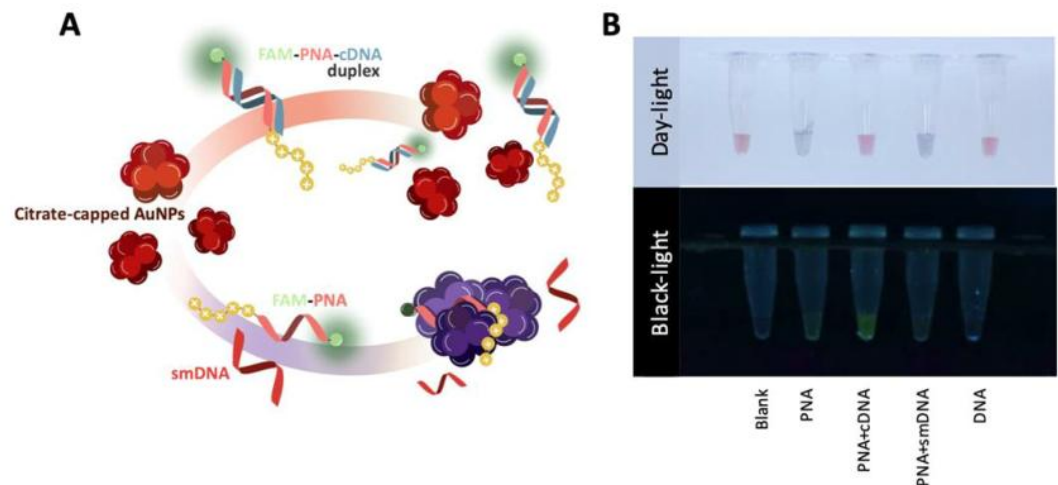


Figure 1.6 Colorimetric detection of nucleic acids based on AuNPs and positively charged labeled PNA in Faikhruea work.³² (Reprinted with permission from *ACS Appl. Bio Mater.* 2022, 5 (2), 789-800. Copyright (2022) American Chemical Society.)

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