

Asking Bing with GPT-4 about the Antibiotic Use of Clays [†]

Carlos Alves 

Lab2PT (FCT-UIDB/04509/2020) and School of Sciences (Earth Sciences Department), University of Minho, 4710-057 Braga, Portugal; casaix@dct.uminho.pt

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Abstract: In this work, Microsoft Bing chat with GPT-4 was used for researching the antibiotic use of clays by submitting three requests that were literally the following: (+) write a bullet list of the most important points concerning research on the use of clay minerals for preparing antibiotics; (+) write a bullet list of suggestions for future and original research, not performed before, on the use of clay minerals for preparing antibiotics; (+) write a bullet list of the most important results of clinical trials of clay minerals as antibiotics. Bing's answers were extensive, containing information on mineralogical and health issues. Bing also suggested follow-up questions, some of which were also included, and that expanded the topics considered to domains of ethics and arguably even politics, with repeated references to “respecting the traditional knowledge and practices of indigenous or local communities that have used clay minerals for medicinal purposes for centuries”, including the answer to the following question suggested by Bing, “How can we improve the antibiotic activity and specificity of clay minerals?”.

Keywords: generative artificial intelligence; applied mineralogy; new antibiotics

1. Introduction

Artificial intelligence chatbots are one of the dominant subjects of the moment, being searched as a source of opportunities and feared as a threat to the world of humans. Scientific research could also benefit from their potentialities, and a recent paper even proposed that they could work as a “hypothesis machine”, which could synergistically work with humans [1]. In the specific case of antibiotics, in a very recent survey, four of the seven experts consulted by The Conversation highlighted the role of artificial intelligence in the discovery of new antibiotics [2]. Here, I attempt to assess the use of generative artificial intelligence regarding the specific and narrow subject of clays as antibiotics.

2. Materials and Methods

The materials in this case are both software and hardware. All the research work (before the final edit) was performed in an Android smartphone with 4 GB RAM (the final text was composed and submitted in a laptop). The chatbot used was Microsoft Bing with GPT-4 [3], which does not require payments, performs real-time searches (with the Bing search engine), and also suggests new questions (hereafter just Bing). The questions and the Bing answers were organized in Dynalist for Android [4].

The method was simply to put questions to the chatbot, and, in some cases, also follow some of the commentary questions suggested by the chatbot. Nonetheless, the choice of the questions is of paramount importance (the old adage “garbage in garbage out” is frequently valid but not always, as the chatbot can correct the input question and even suggest that it should not be formulated in those terms), as is suggested by the enormous quantity of books on prompt engineering, with the Amazon.com webpage indicating at this time (24-October) “coming soon” Kindle titles on the subject, expected as far away as 9 February 2024 [5].



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It is arguably advisable to separate my own text from that of the chatbot. The answers and follow-up questions suggested by Bing are clearly marked; all the rest is mine (including the introduction above), albeit the last question followed a suggestion from Bing in a preliminary essay. While I certainly corrected some points in the language as a result of the preliminary interaction with Bing, the text was not revised by it or any other generative artificial intelligence tool, but it was checked by both Microsoft Word [6] and Google Docs [7] in terms of spelling and grammar. Bing answers are presented as a result and self-contained block, including the proposed references.

3. Results and Discussion

This section is organized around the initial questions to the chatbot, with each making a subsection. I include in each subsection the follow-up question suggested by Bing after an original question.

3.1. Write a Bullet List of the Most Important Points Concerning Research on the Use of Clay Minerals for Preparing Antibiotics

This was the first question, a kind of assessment of the past and the present, to which Bing gave the following answer:

“Some possible points are:—Clay minerals are natural geological nanomaterials that have been used for medicinal and therapeutic purposes since ancient times¹².—Some clay minerals have intrinsic, heat-stable antibacterial properties that can kill or inhibit a broad spectrum of bacterial pathogens, including antibiotic-resistant strains such as MRSA and Bcc¹²⁵.—The antibacterial activity of clay minerals depends on their chemical composition, structure, surface area, ion exchange capacity, and pH¹²⁵.—The mechanism of action of clay minerals against bacteria is not fully understood, but it may involve physical damage to the bacterial cell wall or membrane, release of toxic metal ions, generation of reactive oxygen species, or alteration of the intracellular environment¹²⁵.—Clay minerals may offer a novel and inexpensive alternative to conventional antibiotics, especially for treating infections that are difficult to eradicate with existing drugs, such as Buruli ulcer and cystic fibrosis¹².—Clay minerals may also have environmental benefits, as they may reduce the spread of antibiotic resistance genes and pollutants in soil and water³⁴.(1) Broad-spectrum in vitro antibacterial activities of clay minerals.... <https://academic.oup.com/jac/article/61/2/353/765146> (2) Antibacterial Activity of a Natural Clay Mineral against. <https://www.mdpi.com/2076-2607/11/1/150> (3) Scientists discover how blue and green clays kill bacteria—Phys.org. <https://phys.org/news/2016-01-scientists-blue-green-clays-bacteria.html> (4) Antibacterial Minerals: A geochemical approach to combating antibiotic.... <https://www.osti.gov/biblio/1671175/> (5) Study: Antibiotics hide within soil mineral layers. <https://news.cornell.edu/stories/2016/02/study-antibiotics-hide-within-soil-mineral-layers> (6) undefined. <https://doi.org/10.1093/jac/dkm468> (7) undefined. <https://doi.org/10.3390/microorganisms11010150>”.

Bing gave a clearly structured answer, highlighting critical points in this kind of research, such as their possible contribution to the spread of antibiotics resistance, albeit the history of life suggests that it might be over optimistic to think that bacteria will not develop resistance to the antibacterial effects of clays. However, one can express some reservations right at the very beginning of the answer: while clays indeed comprise small particles, it seems like a significant stretch to use “nanomaterials” for particles with a grainsize upper limit of 2000 nm.

The answer includes apparently seven references, all of which are with working links. However, the last two links refer to the same work as the first two. This bibliography includes very recent work (from this year), albeit two of the references are press releases and not peer reviewed papers (so, at the end, only two papers).

One of the follow-up questions suggested by Bing to this initial question was the very reasonable “Are there any side effects or risks associated with using clay minerals as antibiotics?”. Bing answered its own question as follows:

“Using clay minerals as antibiotics may have some potential benefits, such as killing or inhibiting a wide range of bacteria, reducing the spread of antibiotic resistance, and providing a low-cost and natural alternative to conventional drugs. However, there may also be some side effects or risks associated with this practice, such as:- Clay minerals may contain toxic elements, such as heavy metals, that can be absorbed by the body and cause poisoning or damage to organs¹⁴.—Clay minerals may interfere with the absorption or effectiveness of other medications, such as tetracycline, which can bind to clay minerals and reduce its bioavailability⁵.—Clay minerals may cause physical or chemical damage to the skin or mucous membranes, such as irritation, inflammation, infection, or allergic reactions²³.—Clay minerals may alter the normal flora of the skin or gut, which may affect the immune system and the digestion².—Clay minerals may not be effective against all types of bacteria, especially those that are resistant to oxidative stress or have protective mechanisms¹³.Therefore, using clay minerals as antibiotics should be done with caution and under medical supervision. It is important to choose the appropriate type and quality of clay minerals, to avoid contamination and adulteration, to follow the recommended dosage and duration of treatment, and to monitor the possible adverse.

(1) NATURAL ANTIBACTERIAL CLAYS: HISTORICAL USES AND MODERN ADVANCES—Springer. <https://link.springer.com/article/10.1007/s42860-018-0002-8>
 (2) Clay Supplement: Uses, Benefits, Side Effects, Dose...—MedicineNet. <https://www.medicinenet.com/clay/supplements-vitamins.htm> (3) Tetracycline (Antibiotics) Uses, Dosage, Side Effects—Drugs.com. <https://www.drugs.com/tetracycline.html> (4) BENEFITS AND RISKS OF CLAYS AND CLAY MINERALS TO HUMAN...—Springer. <https://link.springer.com/article/10.1007/s42860-021-00160-7> (5) Geomimicry: harnessing the antibacterial action of clays | Clay.... <https://pubs.geoscienceworld.org/claymin/article/52/1/1/311561/geomimicry-harnessing-the-antibacterial-action-of>”.

It is interesting that at the beginning of the answer, Bing refers to clays as a potential “natural” alternative, a perspective which does not seem evident in the answer to the initial question. This could be part of what Levinovitz [8] “calls Faith in Nature’s Goodness” and, perhaps, an early sign of some general political trends in Bing’s answers.

This answer highlights a known issue with clays (fixation of pollutants) and other topics to be considered in the development of health products in general. Bing presents five references, but only three of them are scientific papers, all being reviews (two from the same author).

3.2. Write a Bullet List of Suggestions for Future and Original Research, Not Done before, on the Use of Clay Minerals for Preparing Antibiotics

This question was a look at the likely future, and the following was the chatbot’s answer:

“Some possible suggestions for future and original research on the use of clay minerals for preparing antibiotics are:—To investigate the synergistic or antagonistic effects of combining clay minerals with other antibiotics, natural products, or nanoparticles, and to evaluate their efficacy and safety against multidrug-resistant bacteria.—To develop novel formulations and delivery systems of clay minerals, such as gels, creams, ointments, patches, films, capsules, or injectables, and to optimize their stability, bioavailability, biocompatibility, and biodegradability.—To conduct clinical trials and epidemiological studies to assess the therapeutic outcomes, adverse reactions, and cost-effectiveness of using clay minerals as antibiotics for various infectious diseases, such as skin infections, wound infections, gastrointestinal infections, respiratory infections, or urinary tract infections.—To elucidate the ecological and evolutionary impacts of using clay minerals as antibiotics on the microbial communities and the environment, and to monitor the emergence and dissemination of antibiotic resistance genes and pollutants.—To explore the potential applications of clay minerals as antibiotics in other fields, such as agriculture, veterinary medicine, food preservation, or biotechnology”.

Bing presents several suggestions addressing important points, but they can be considered very generalist and be valid for any other substance.

One of the follow-up questions suggested by Bing was “Are there any ethical concerns associated with using clay minerals as antibiotics?”, with the following answer:

“Using clay minerals as antibiotics may raise some ethical concerns, such as:—The potential harm to human health and the environment from the exposure to toxic elements or pollutants that may be present in some clay minerals or released by their interaction with bacteria¹².— The possible interference with other treatments or medications that may be affected by the adsorption or alteration of clay minerals¹².—The lack of regulation and standardization of the quality, safety, and efficacy of clay minerals as antibiotics, especially for those sold online or in alternative medicine markets².—The possible exploitation or appropriation of the traditional knowledge and practices of indigenous or local communities that have used clay minerals for medicinal purposes for centuries²³.—The potential risk of creating new forms of antibiotic resistance or altering the microbial balance and diversity by using clay minerals indiscriminately or excessively²³.Therefore, using clay minerals as antibiotics should be done with caution and respect, and only after careful evaluation of the benefits and risks involved. It is also important to conduct more research on the antibacterial mechanisms and applications of clay minerals, as well as their ethical and social implications. (1) Competitive Association of Antibiotics with a Clay Mineral and.... <https://pubs.acs.org/doi/pdf/10.1021/acsomega.8b02049>. (2) NATURAL ANTIBACTERIAL CLAYS: HISTORICAL USES AND MODERN ADVANCES—Springer. <https://link.springer.com/article/10.1007/s42860-018-0002-8>. (3) Geomimicry: harnessing the antibacterial action of clays | Clay.... <https://pubs.geoscienceworld.org/claymin/article/52/1/1/311561/geomimicry-harnessing-the-antibacterial-action-of>. (4) undefined. <http://pubs.acs.org/journal/acsofd>”.

It is interesting that Bing raises the problem of the lack of regulation and standardization typical of alternative medicine markets.

Bing also seems to be checking one of the current mandatory political points. There is no way a traditional use will be approved for medical purposes without extensive clinical trials, except, of course, the alternative medicine market. Obviously, it is a mandatory principle for researchers to indicate the shoulders which allow them to see farther.

3.3. Write a Bullet List of the Most Important Results of Clinical Trials of Clay Minerals as Antibiotics

This question was a look at the likely future, and the following was the chatbot’s answer:

“Some possible results of clinical trials on the use of clay minerals as antibiotics are:—A clinical trial conducted in Uganda showed that a natural clay mineral (KC) and its aqueous extract had significant antibacterial activity against Burkholderia cepacia complex (Bcc), Pseudomonas aeruginosa, and Stenotrophomonas maltophilia, which are common pathogens in cystic fibrosis patients. The clay mineral and its extract reduced the bacterial load and biofilm formation, and improved the lung function and quality of life of the patients³.—A clinical trial conducted in France showed that a synthetic antibacterial mineral (SAM) based on montmorillonite clay and silver nanoparticles had potent antibacterial activity against the ESKAPE pathogens (Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species), which are responsible for most hospital-acquired infections. The SAM mineral killed or inhibited the growth of the bacteria, even those that were resistant to multiple antibiotics. The SAM mineral also showed low toxicity and good biocompatibility with human cells⁵.—A clinical trial conducted in China showed that a nanocomposite material based on halloysite clay and chitosan had antibacterial activity against Staphylococcus aureus and Escherichia coli, which are common causes of wound infections. The nanocomposite material enhanced the wound healing process by promoting blood clotting, reducing inflammation, stimulating tissue regeneration,

and preventing infection. The nanocomposite material also showed good biodegradability and biocompatibility with skin tissue⁴. (1) Antibacterial Activity of a Natural Clay Mineral against. <https://www.mdpi.com/2076-2607/11/1/150> (2) Synthetic antibacterial minerals: harnessing a natural geochemical.... <https://www.nature.com/articles/s41598-022-05303-x.pdf> (3) Antimicrobial Nanomaterials Based on Halloysite Clay Mineral...—MDPI. <https://www.mdpi.com/2079-6382/11/12/1761> (4) NATURAL ANTIBACTERIAL CLAYS: HISTORICAL USES AND MODERN ADVANCES—Springer. <https://link.springer.com/article/10.1007/s42860-018-0002-8> (5) Competitive Association of Antibiotics with a Clay Mineral and.... <https://pubs.acs.org/doi/pdf/10.1021/acsomega.8b02049> (6) undefined. <http://pubs.acs.org/journal/acsofd>".

As can be seen, three cases were indicated, one of natural clay in Uganda and two from synthetic substances (France and China). While there is clear information on the microbial issue and results, regarding clay characteristics, it is almost telegraphic. In the first case, there are no indications of the mineralogical characteristics, but this is a result of the lack of that information in the cited work. I was unable to understand the role of the sixth reference in this answer.

In this subsection, I also include one of Bing's follow-up questions: how can we improve the antibiotic activity and specificity of clay minerals? Its answer was as follows:

"How can we improve the antibiotic activity and specificity of clay minerals? Improving the antibiotic activity and specificity of clay minerals is a challenging task, as there are many factors that influence their antibiotic properties and potential risks. Some possible steps that could be taken are:—Identifying and characterizing the antibiotic mechanisms of different types of clay minerals, such as their chemical composition, structure, surface area, ion exchange capacity, pH, redox potential, and reactive oxygen species generation¹².—Optimizing the synthesis and modification of clay minerals to enhance their antibiotic activity and specificity, such as by incorporating metal nanoparticles, organic molecules, or biomolecules that can target specific bacterial receptors or enzymes²³.—Developing novel formulations and delivery systems of clay minerals, such as gels, creams, ointments, patches, films, capsules, or injectables, and optimizing their stability, bioavailability, biocompatibility, and biodegradability²⁴.—Conducting rigorous clinical trials and epidemiological studies to evaluate the therapeutic outcomes, adverse reactions, and cost-effectiveness of using clay minerals as antibiotics for various bacterial diseases, such as skin infections, wound infections, gastrointestinal infections, respiratory infections, or urinary tract infections²³.—Implementing strict regulations and quality control measures to ensure the purity, safety, and efficacy of clay minerals as antibiotics, especially for those sold online or in alternative medicine markets². This may include verifying the source and origin of the clay minerals, screening for toxic elements or contaminants, labeling the ingredients and warnings, and monitoring the shelf life and stability of the products²⁴.—Promoting ethical and responsible use of clay minerals as antibiotics, such as respecting the traditional knowledge and practices of indigenous or local communities that have used clay minerals for medicinal purposes for centuries², avoiding overuse or misuse that may lead to environmental or health problems², and educating the public and health professionals about the benefits and risks involved². (1) Broad-spectrum in vitro antibacterial activities of clay minerals.... <https://academic.oup.com/jac/article/61/2/353/765146> (2) Antibacterial Activity of a Natural Clay Mineral against. <https://www.mdpi.com/2076-2607/11/1/150> (3) Minerals | Free Full-Text | Microbial Interaction with Clay Minerals.... <https://www.mdpi.com/2075-163X/10/10/861> (4) undefined. <https://doi.org/10.1093/jac/dkm468> (5) undefined. <https://doi.org/10.3390/microorganisms11010150>".

There is again a reference to the special control of alternative markets. Here, Bing seems to waddle again into political waters. It is beyond my abilities to understand the relevance of "respecting the traditional knowledge and practices of indigenous or local communities" to the question under consideration. Obviously, one should consider and

test all available information, and that does include seeking information from past use. These instances might, perhaps, be part of what has been called “woke washing” [9], with the inclusion of certain key phrases perceived as socially responsible in a marketing or public relations strategy.

4. Final Considerations

The generative artificial intelligence, Bing with GPT-4, was able to present significant important points in relation to the current state of the art. While the “natural” perspective was floated once, it showed a remarkable and laudable concern with alternative markets, albeit it seems to believe that it will be possible to apply a more stringent control on the market. Depending on one’s political perspectives, Bing either mixes irrelevant information for political purposes or adds sentences that satisfy the political points “du jour”. Perhaps surprisingly, Bing did not make any reference to land acknowledgements (perhaps because it is almost exclusively a North American trend). In relation to new perspectives and hypotheses, there have been some interesting suggestions formulated in a very generalist form. It is possible that further questioning might produce more specific information. Indeed, as the publishing market is suggesting, prompt engineering could be a critical component of the development of generative artificial intelligence.

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