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Literature review: the role of magnetic nanoparticles in several areas of life

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ABSTRACT

There has been a lot of research on nanoparticles that have been developed to be applied to everyday life. One of the types of nanomaterials already discussed is magnetic nanoparticles. Some areas of life that apply the application of magnetic nanoparticles are in the medical and biological fields, sensor fields, water and sewage treatment fields, and others. The results of this literature review discuss the role of magnetic nanoparticles in everyday life.

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1. INTRODUCTION

Nanotechnology is the study and engineering of materials with their functional structures on the nanometer scale [1]–[7]. Research on nano-sized materials, also called nanomaterials, is research that is always related to the development of nanorechnology. The division of nanomaterials itself is divided into various types. three classifications according to their dimensions, namely, nanomaterials with Dimension zero or commonly called nanopaerticles; nanomaterials with Dimension one for example nanowires, nanorods, and nanotubes; nanomaterials with Dimension two such as thin films; as well as three-dimensional nanomaterials such as microporous, nanocomposite, nanograined, and others [8]–[15].

At the end of these 2 decades, magnetic nanoparticles, with a size of 1 to 100 nm, become important nanoparticles for science and technology. Magnetic nanoparticles are widely studied because they have many unique characteristics, such as high surface-to-volume ratios and size-dependent magnetic properties that are drastically different from those of their materials of origin [16].

Magnetic nanoparticles are part of nanoparticles that belong to zero–dimensional nanomaterials, and can be manipulated using magnetic fields [17] - [26]. This type of Material usually has two components, it is a magnetic material and its chemical components have functional groups . Magnetic nanoparticle clusters are magnetic bases that are assembled into magnetic nanoscale chains. magnetic nanoparticles have been the focus of a variety of renewable research because the material has unique properties that can be used as potential catalysts, biomedicine and tissue-specific targeting, colloidal photonic cryals that can be arranged magnetically, micro fluids, nano fluids, data bases, optical filters, defect sensors, cation sensors, and others[27]–[31].

In this literature review, we will discuss the characteristics of magnetic nanoparticles, and their benefits in today's era.

Nanopartikel magnetic juga banyak digunakan untuk mengatasi masalah-masalah lingkungan. Berikut beberapa contoh aplkasi nanopartikel magnetic dalam lingkungan khususnya untuk menurnian air.

Nanopartikel Fe3O4 yang dilapisi oleh silika menjadi Fe3O4@SiO2 coreshell telah dilaporkan oleh (Machfiro, 2020) bahwa partikel tersebut dapat menjadi absorban logam Cu2+ dalam air. Disampaikan bahwa nilai kapasitas dari absorbsi akan semakin menurun dan semakin besarnya nilai efisiensi absorbsinya jika semakin besar komposisi dari Fe3O4@SiO2.

Selanjutna penelitian tentang tentang pemurnian air juga dilakukan oleh [37]. Dalam penelitian ini, nanopartikel magnetic FeO yang dicampur dengan Mn, Co, atau Cu dipakai unruk menghilangkan patogen mikroorganisme dalam air. Nanoartikel FeO lebih efisien menyisihkan S. aureus daripada bakteri E. coli. Dibuktikan bahwa penggunaan nanopartikel magnetic tersebut sederhana dan murah.

Bidang Tumbuhan dan Hewan

Pengaplikasian nanopartikel magnetic juga berlaku juga pada makhluk hidup.

Dalam jurnalnya, (Zadeh dkk., 2019), telah melakukan penelitian tentang pengatuh nanopartikel magnetic Fe3O4 pada tanaman tomat yang mengandung kadium. Kadium dapat menimbulkan tekanan untuk tanaman, sehingga penambahan Fe3O4 bertujuan untuk mengurangi tekanan tersebut. Kesimpulan yang diperoleh adalah penambahan Fe3O4 dapat mengurangi tekanan kadium pada tiga bagian, yaitu, pengurangan kadium terakumulasi yang terdapat padda akar dan pucuk, mengurangi tekanan oksidasi karena penurunan kadium yang terakumulasi, dan mengatur penyerapan elemen nutrisi yang melindungi tekanan oksidasi.

Selanjutnya, salah satu aplikasi nanopartikel magnetic pada dunia animalia yaitu pada kajian pustaka yang dilakukan oleh [39]. Dalam jurnal tersebut, dikutipkan dari penelitian yang dilakukan oleh Sizova bahwa terdapat salah satu nanomateial magnetic yaitu Fe berperan sebagai suplemen yang terdapat pada pakan ayam memiliki dampak dalam meningkatnya berat badan ayam dan memperbaiki raiso konversi pakan (FCR). Selain itu juga disebutkan bahwa Fe juga dapat digunakan untuk mensintesis hemogoblin, juga sebagai pengangkut beberapa enzim, miogoblin, dan oksigen pada jaringan tubuh hewan.

Bidang Makanan

Penelitian yang dilakukan oleh (Alam dkk., 2018) tentang enzim asparaginase yang dikonjugasi oleh nanopartikel magnetic digunakan untuk ngurangi formasi akrilamida pada system model makanan. Akrilamida merupakan karsinogen yang bersifat sitotoksik dan berbahaya apabila dikonsumsi dengan dosis tinggi. Keracunan akrilamida dapat menyebabkan kematian pada sel. Akrilamida terbentuk ketika makanan dipanaskan saat dipanggang atau ketika digoreng. Hasil yang didapat padda penelitian ini adalah bahwa enzim asparaginase terimobilisasi bebas pada nanopertikel magnetik silan melalui metode kovalen. Imobilisasi tersebut meningkatkan efisiensi katalis, reusability, dan stabilitas termal enzim. Asparaginase yang dilumpuhkan oleh nanopartikel magnetic menjadi biokatalis yang efisien untunk mengurangi akrilamida dalam sistem model makanan pati-asparagin dibandingkan dengan asparaginase bebas

2. Synthesis Of Magnetic Nanoparticles

Synthesizing magnetic nanoparticles aims to convert large-sized particles into nano-sized particles, or about 1 to 100 nm. In addition, synthetic magnetic nanoparticles aim to change the function and properties of these nanoparticles. There is a wide range of magnetic nanoparticle synthesis that can be done. Broadly speaking, nanoparticle synthesis is divided into two main methods, namely physical synthesis method and chemical synthesis method [17]–[22]. The physical synthesis method is a method based on the top-down concept, which means that synthesis starts from bulk materials that are converted into magnetic nanoparticles. While the chemical and biological method is a synthesis method with a bottom-up approach, where atoms or molecules are assembled to form nano-sized particles. The types of the two approaches of the synthesis method are shown in Table 1.

Table 1 synthesis methods of magnetic nanoparticles

Approach	Methods	Jenis
Top-down	Physics	*Electron beam lithography, gas-phase deposition electrical explosion of wires, mechanical milling, electron beam lithography*
Bottom-up	Chemistry	*Vapor deposition and patterning, spray pyrolysis, laser pyrolysis, co-preparation, thermal decomposition* *Microemulsion, sol-gel method hydrothermal/solvothermal method., polyol method, non-thermal plasma method*
	Biologi	*Microbes, plants, templates (DNA, membranes etc.)*

The methods certainly have their own disadvantages and advantages. Physical and chemical methods require high costs. In addition, compared with the physical method, the chemical synthesis method has wide applicability. However, these methods have adverse effects on the environment, that is, the formation of their by-products or toxic substances that can harm a certain environment can also cause toxicity to humans. Currently being developed many methods of synthesis of nanoparticles biological methods known as 'green synthesis". The method is considered beneficial because the ingredients needed are many produced naturally. However, this method needs further discussion so that there are no new risks and tosicity (Shukla et al., 2021).

3. Applications Of Magnetic Nanoparticles

The following are applications of nanoparticles in several areas of life.

Biomedical Field

One of the fields with the most utilization of magnetic nanoparticles is the medical field because of their diverse physiochemical properties, easy to prepare, high stability, and biocompatibility (Ali et al., 2021).

Magnetic nanoparticles are classified into pure metals, oxidized metals, and magnetic nanocomposites. The most famous magnetic nanoparticles in the medical field are Fe, Co, Ni, Ti, iron oxide, and some ferrites such as CoFe2O4 and BaFe12O19. Among them, iron oxide magnetic nanoparticles are widely used because of their low toxicity properties (Cardoso et al., 2017).

In the journal, (Ziarani et al., 2019), has summarized the usefulness of hollow magnetic nanoparticles (HMN) as a drug delivery product in detail. Table 2 shows the modifications of cavitary nanoparticles used in some types of drugs.

Table 2 HMP modifications to drugs

Group	Types of drugs	Modification of HMN
Obat herbal tradisional	Rhodamine B	$\gamma - Fe_2O_3@SiO_2$
	Rhodamine 6G	Fe_3O_4/PAA
Obat antiinflamasi nonsteroid	Ibuprofen	*Metal oxides*
		Ferrit
	Sodium meclofenamate	Nanokapsul magnetik berongga
Antibiotik	Cefradine	$Fe_3O_4/PE_5/CdTe/TE_1$
	Vancomycin	HAp
	Enrofloxacin	MHMs
Antikanker	Doxorubicin	HMNPs
	Cisplatin	(HMs-CMCs)
	Camptothecin	HMMNs
	Paclitaxel	HPNs
	Docetaxel	MMCN
	5-Fluorouracil	$Fe_3O_4\ /\ TSCHMs$

Environmental Field

Magnetic nanoparticles are also widely used to solve environmental problems. Here are some examples of applications of magnetic nanoparticles in the environment, especially to reduce water.

Fe3O4 nanoparticles coated by silica become Fe3O4@SiO2 coreshell it has been reported by (Machfiro, 2020) that the particles can become Cu2+ metal absorban in water. It is said that the value of absorption capacity will decrease and the greater the value of absorption efficiency if the greater the composition of Fe3O4@SiO2.

Further research on water purification is also carried out by [37]. In this study, FeO magnetic nanoparticles mixed with Mn, Co, or Cu were used to eliminate pathogenic microorganisms in water. FeO nanoarticles more efficiently cull S. bacteria from E. coli. Col. It is proved that the use of such magnetic nanoparticles is simple and inexpensive.

Field of plants and animals

The application of magnetic nanoparticles also applies to living things.

In his journal, (Zadeh et al., 2019), has conducted research on the adherence of Fe3O4 magnetic nanoparticles in tomato plants containing cadium. Kadium can cause stress for plants, so the addition of Fe3O4 aims to reduce the pressure. The conclusion obtained is that the addition of Fe3O4 can reduce the pressure of cadium in three parts, namely, reducing the accumulated cadium contained in the roots and shoots, reducing the oxidation pressure due to the decrease in accumulated cadium, and regulating the absorption of nutrient elements that protect the oxidation pressure.

Furthermore, one of the applications of magnetic nanoparticles in the animal world is in a literature review conducted by [39]. In the Journal, quoted from research conducted by Sizova that there is one magnetic nanomateial, Fe acts as a supplement contained in chicken feed has an impact on increasing chicken weight and improving feed conversion rate (FCR). It is also mentioned that Fe can also be used to synthesize hemogoblin, as well as transporting several enzymes, myogoblin, and oxygen in animal body tissues.

Food Field

Research conducted by (Alam et al., 2018) about the enzyme asparaginase conjugated to magnetic nanoparticles used to reduce acrylamide formation in food model systems. Acrylamide is a carcinogen that is cytotoxic and dangerous when taken in high doses. Acrylamide poisoning can lead to cell death. Acrylamide is formed when food is heated during baking or when fried. The results obtained in this study is that asparaginase enzyme is immobilized freely on silane magnetic nanoperticles through covalent method. Such immobilization improves catalyst efficiency, reusability, and thermal stability of enzymes. Asparaginase immobilized by magnetic nanoparticles becomes an efficient biocatalyst to reduce acrylamide in the starch-asparagine food model system compared to free asparaginase.

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4. CONCLUSION

The above is a small sample of the applications of magnetic nanoparticles that have been reported by scientists. There are many more benefits of magnetic nanoparticles that can be studied further. The concept of nanoparticles themselves, namely nano-sized particles, is a material that has been very advanced in today's time. In addition, because of the advantages of these materials such as electrical, optical, magnetic, and chemical properties are ideal so that they are superior to other materials.

Applications of magnetic nanoparticles are already reaching the bodies of living things on a large scale, so it is necessary to dialmbil further security measures to protect human health and the surrounding environment.

DECLARATION

Supplementary Materials

The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Figure S1: title; Table S1: title; Video S1: title.

Author Contribution

All authors contributed equally to the main contributor to this paper. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

Declare conflicts of interest or state "The authors declare no conflict of interest."

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