Application of graphene in electrical resistance electromagnetic shielding fabric

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Abstract: Graphene is a kind of material formed by Sp2 hybridization of carbon atoms, which has been widely used in various scientific research fields in recent years. In this paper, the mechanism of electromagnetic shielding on fabrics and the recent development of resistance type electromagnetic shielding materials are introduced. The effects of graphene and metal particle composites, graphene and high conductivity polymer composites, carbon nanotubes and high conductivity polymer composites on fabrics are briefly described. The optimization of electromagnetic shielding effectiveness and the future development of shielding materials is prospected.

1 Introduction
With the continuous development of science and technology, the use of various electronic devices has brought great convenience to people's production and life. Meanwhile, the electromagnetic radiation and interference generated during the working process of electronic equipment will affect people's production and life, causing humans to live in an environment full of electromagnetic waves, making it a new source of pollution after water, air, and noise pollution. It will not only affect normal communication, but also cause irreversible damage to the human central nervous system, sympathetic nerves, and the genetic sequence of the genome. Humans usually wear clothing to reduce the damage of electromagnetic waves to the body. However, ordinary clothing has only weak or no electromagnetic shielding effect. Therefore, we need to post-process ordinary fabrics to achieve electromagnetic shielding effect.

At present, the preparation methods of conductive textiles in the textile field[1] can be mainly divided into the production of conductive fibers or yarns to prepare conductive textiles: the production of conductive fibers can be roughly divided into four types: ①Metal fibers ②Metal salt conductive fiber ③High polymer conductive fiber [2][3]④Containing carbon fiber or carbon black and polymer composite conductive fiber.

This article mainly describes the electromagnetic shielding mechanism and the electromagnetic shielding materials containing graphene (graphene, metal powder, carbon nanotubes and conductive polymers) deposited on the fabric, which can act as electromagnetic material without affecting the flexibility and wearability.

2 Electromagnetic shielding mechanism
The phenomenon that the energy in the electromagnetic field is emitted in the form of 30~30000 MHz electromagnetic waves is called electromagnetic radiation[6]. When electromagnetic waves encounter
obstacles in the process of propagation, the energy is attenuated by the reflection and absorption of the obstacles. Generally, the shielding effect of a shielding material on a certain point in space is expressed by shielding effectiveness (SE), that is, SE=20 lg (E0/E) (E0 is the field strength of the point when there is no shielding material, and E is the Point field strength).

As long as the SE of the fabric is greater than 30 dB, it has electromagnetic shielding effectiveness. When the electromagnetic wave propagates to the surface of the shielding material, it is generally attenuated according to three different mechanisms: The reflection loss of the electromagnetic wave on the incident surface; The loss of the electromagnetic wave that is not reflected but enters the shield and is absorbed by the material; In the shield internal multiple reflection loss. As shown in Figure 1.

3 Electromagnetic wave absorbing materials

Electromagnetic shielding on the fabric generally uses resistive absorbing materials. Resistive absorbing materials [10][11] mainly absorb electromagnetic waves through interaction with electric fields. The conductance and dielectric constant of the material determine the efficiency of absorbing electromagnetic waves. Resistance-type absorbing materials. Its main feature is that [12][13] it has a high loss tangent and relies on the polarization attenuation of the medium to absorb electromagnetic waves. In actual use, most of the absorbing materials are mixed in a certain proportion to improve the electromagnetic shielding effectiveness.

3.1 Graphene and metal particle type

Graphene (GF) [14][15] is a new material with a two-dimensional honeycomb structure consisting of a single layer or a few layers of carbon atoms that are closely packed and arranged. The atoms are connected in the form of covalent bonds.

Zhao Hongtao [16] used electrophoretic deposition (EPD) to deposit graphene oxide (GO) on a plain weave cotton fabric and then converted it into reduced graphene oxide (r-GO) by heat treatment, and then The fabric, modified the graphene on the cotton, is immersed in AgNO3/polyvinilpyrrolidone (PVP) mixed solution, and then ascorbic acid is added to react for 30 minutes. Then take it out, wash, and dry to obtain the Ag/r-GO/cotton composite fabric, and finally coat with a layer of water-soluble polyurethane (PET). When AgNO3 is 0.25 Wt%, the conductivity of Ag/r-GO/cotton is 145 S/m. (The conductivity of the original cotton is 0.33 S/m). The conductivity of the Ag/r-GO/cotton composite fabric (CGAP) fabric is about 400 times higher than that of the original cotton. It was found that the number of dipping and r-GO/Ag with the increase of the mass percentage of the prepared r-GO/Ag cotton fabric increases.

3.2 Graphene and highly conductive polymer type
Zou Lihua et al. [17] used the layer-by-layer assembly method to coat graphene oxide (GO)/polyaniline (PANI) on the surface of cotton fabric. The electromagnetic shielding effectiveness of the fabric is continuously improving, and with the increase of the graphene oxide concentration, the shielding performance of the fabric first increases and then decreases; when the assembly of 4 layers of GO/PANI functional film, the shielding effectiveness can reach 98.98%. Sun Jiariu [18] used a direct coating method to prepare polyaniline/graphene (PANI-GO) composite coating fabric. In the range of 0.2~1.0 GHz, as the frequency increases, the real part of the fabric's dielectric constant gradually decreases. The polarization ability of fabrics to electromagnetic waves basically increases first and then weakens, and the loss and absorption of electromagnetic waves gradually increase. After adding graphene, the dielectric properties of the fabric have been improved. When the graphene content is 10%~15%, the improvement is most obvious. It can be seen that the electromagnetic shielding effect of graphene and highly conductive polymer composite fabric is better than pure fabric.

3.3 Carbon nanotube and metal particle type

In the 1990s, S. Iijima [19] of NEC Laboratory in Tsukuba, Japan, observed under a transmission electron microscope a nano-carbon material with a special structure—carbon nanotubes.

Jianming Yang [20] et al. prepared a 0.5~2 mm thick methyl vinyl rubber VMQ/Fe3O4@MWCNT/Ag@ Waterless cloth composite material through layered structure construction. The thickness is 2 mm in the range of 2~18 GHz. The density is 0.38 g cm\(^{-3}\), and its electromagnetic shielding effectiveness exceeds 90 dB. When the electromagnetic radiation is at 8 GHz and the thickness is 1 mm, the composite exhibits an extremely low reflectivity of 2.6 %, which means that 97.4 % of the electromagnetic radiation is absorbed. The above experiments have proved that the composite material formed by carbon nanotubes and metal particles coated on the fabric has a relatively good electromagnetic shielding effect.

4 Conclusion

At present, the research of electromagnetic shielding materials at home and abroad has made great progress. While the traditional electromagnetic shielding materials are gradually mature and applied, the development of new electromagnetic shielding is also increased. However, due to the immature production methods The prepared electromagnetic shielding fabric still has the problems of easy shedding of electromagnetic shielding material, poor hand feeling and poor air permeability. Especially the color of graphene brings certain difficulties to the dyeing of fabrics. For existing magnetic metal particles or conductive metals, their particle size and morphology should be optimized. Exploring the principle of wave absorption is an effective way to improve absorption efficiency.

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