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Study on the application of graphene in cement matrix composites

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Abstract: In the rapid development of information technology, communication electronic equipment as one of the indispensable tools for people's life and work, although the transformation of the traditional communication technology mode, but also produced a lot of electromagnetic wave pollution. From the perspective of the normal living and working environment of human beings, mass electromagnetic wave pollution will not only cause harm to human life and health, but also threaten the application quality of electronic equipment and data information. In this paper, on the basis of understanding the structural characteristics and application status of graphene, the cement based composites were experimentally analyzed by using graphene oxide (GO), nano-Fe3O4 and reduced graphene-Fe3O4 hybrid material (RGO-Fe3O4), and the effects of the types and output of nanomaterials on the electromagnetic shielding performance and hydration process composition were mainly discussed. The final experimental results show that when the doping amount of RGO-Fe3O4 reaches 0.05%, the electromagnetic shielding efficiency of cement pattern can reach the highest. Among them, GO acts as a template for cement hydration process, and the early hydration has the most significant effect.

Keywords: Graphene; Cement base; Composite material; Graphene oxide; Electromagnetic shielding

1. Introduction

Nowadays, cement-based composite materials applied at home and abroad have begun to develop in the direction of intelligence, high performance and long life. Cement-based electromagnetic shielding materials are just one of the directions. Due to the high resistivity of ordinary cement products after being completely dried, they do not have electromagnetic shielding performance, so scientific researchers propose to add appropriate conductive medium or magnetic conductive medium to cement in order to achieve the purpose of electromagnetic shielding. Graphene has a large surface area, a light density, and a large number of exposed chemical bonds, which are easily weakened by the polarization relaxation of the outer electrons in the electromagnetic field. For example, in the study of Ling et al., GO was synthesized using a modified Hummers method, and graphene/epoxide compounds were constructed by in situ recombination, and then the GO was completely reduced after annealing for two hours in a nitrogen environment at 250 ° C to improve the conductivity of the compounds. The electromagnetic shielding performance of the composites with different graphene doping amounts at 8.2ghz to 12.4ghz was studied. The final results show that the electromagnetic shielding of the composites can reach -21dB when the doping amount of graphene reaches 15wt%. Therefore, graphene is widely used in the field of electromagnetic shielding and wave absorbing materials. Compared with the traditional applied materials, graphene can fully meet the needs of absorbing materials.[1.2.3]

As a kind of absorbing material of double complex medium, ferrite has two effects on electromagnetic wave: magnetic loss and dielectric loss, so it has good absorbing performance. However, from the perspective of experimental study, the saturation magnetization Ms of ferrite is relatively low, which is only 1/5 to 1/3 of that of pure iron. At the same time, ferrite materials have extremely high density and low temperature stability, which directly limit its application performance. Nowadays, ferrite wave absorbing materials begin to develop in the direction of composite and nano. In the process of material modification or composite treatment with different loss mechanisms, the material density of ferrite is effectively reduced, and the wave absorbing

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performance is improved. Zhou et al. regarded graphite and $FeCl_3 \cdot 6H_2O$ as raw materials, and used hydrothermal method to produce graphene /$FeCl_3 \cdot 6H_2O$ composite powder in one step. By changing the initial concentration of Fe^{3+}, the size and dispersion density of Fe_3O_4 were effectively regulated. The final experimental results show that the saturation magnetization (Ms) and coercivity (He) of graphene-Fe_3O_4 can reach 45.5 emU •g^{-1} and 520E, respectively, showing strong magnetism when interacting with an external magnetic field.[4.5.6]

As the most widely used structural engineering material at the present stage, cement-based composites have the characteristics of low tensile strength and high brittleness, and there are many cracks in engineering applications, which leads to lower and lower mechanical properties and application life. The common manufacturing process is shown in Figure 1 below. Typically, fibers are added to cement composites to form a dense system of microporous structures that reduce the formation of large cracks. However, fiber can not prevent the formation of nanodimension cracks, which can not fundamentally solve the high brittleness of cement-based composites. With the rapid development of modern science and technology, nanomaterials are gradually known to people. As a carbon allotrope, the graphene studied in this paper is composed of a single layer of carbon atoms arranged in a honeycomb lattice structure. It is only one carbon atom thick, and is the thinnest two-dimensional nanocrystal material in the world at present. In 2004, Professor Geim and Dr Novoselow of the University of Manchester in the UK were the first to successfully obtain stable graphene crystals by repeated peeling of tape, making the theory a reality. As a hotspot of current technology research, graphene has attracted the research interest of scholars from all over the world on graphene cement and composite materials.

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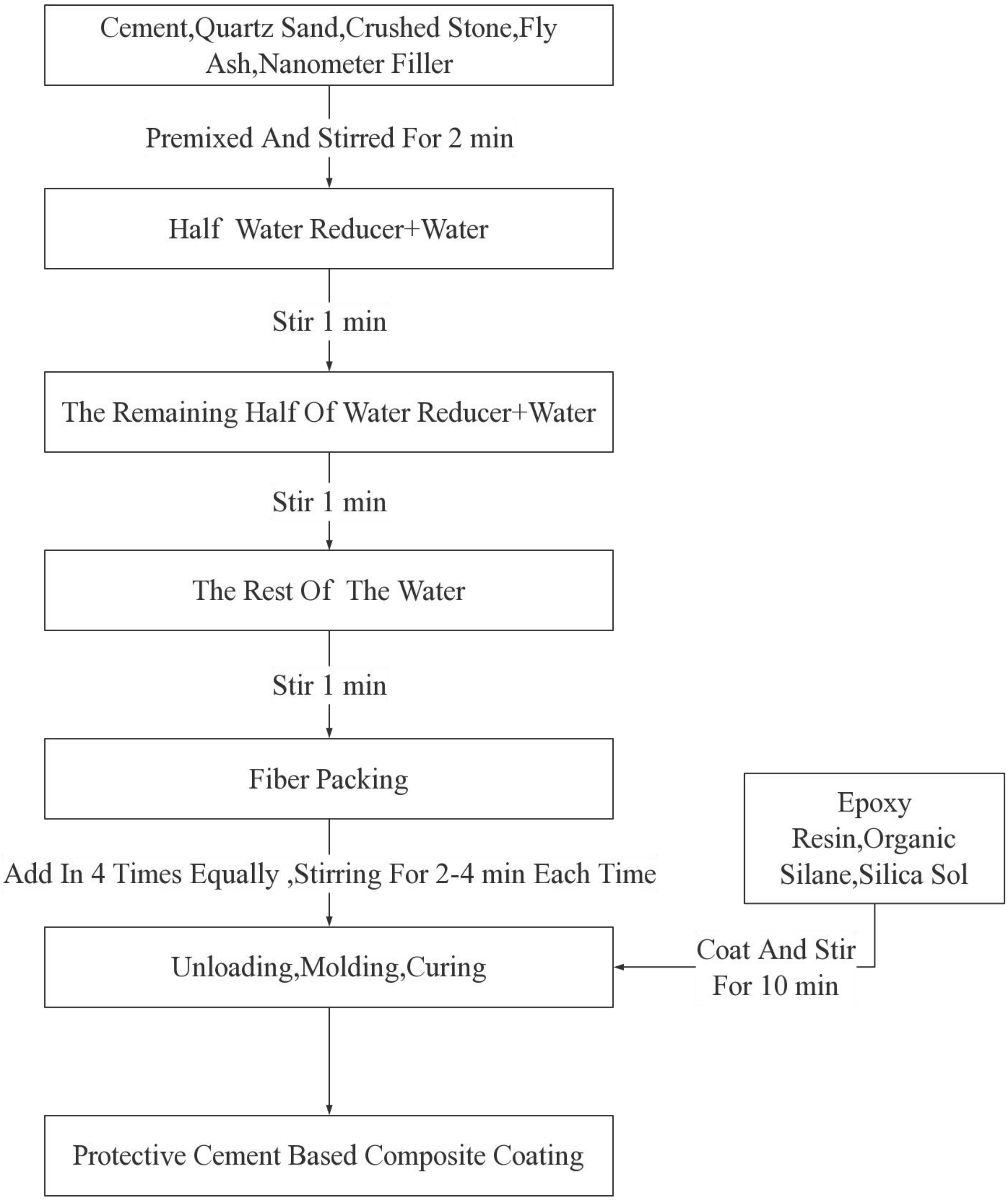

FIG. 1 Flowchart of cement-based composite

Therefore, on the basis of understanding the properties of graphene and cement-based composites, this paper takes cement paste as the matrix, uses three kinds of dopants to make corresponding cement-based composites, and tests the electromagnetic shielding performance of materials at one time.

2. Method

2.1 Experimental raw materials

In this research experiment, graphene is regarded as the main content, and the improved Hummers method is used for independent development in the laboratory. The detailed process is shown in Figure 2 below. Among them, analytical pure and absolute ethanol came from a reagent factory in Tianjin, polyvinylpyrrolidone and analytical pure came from Sinopdirty Chemical Reagent Co., LTD. Ordinary Portland cement was purchased directly in the market.

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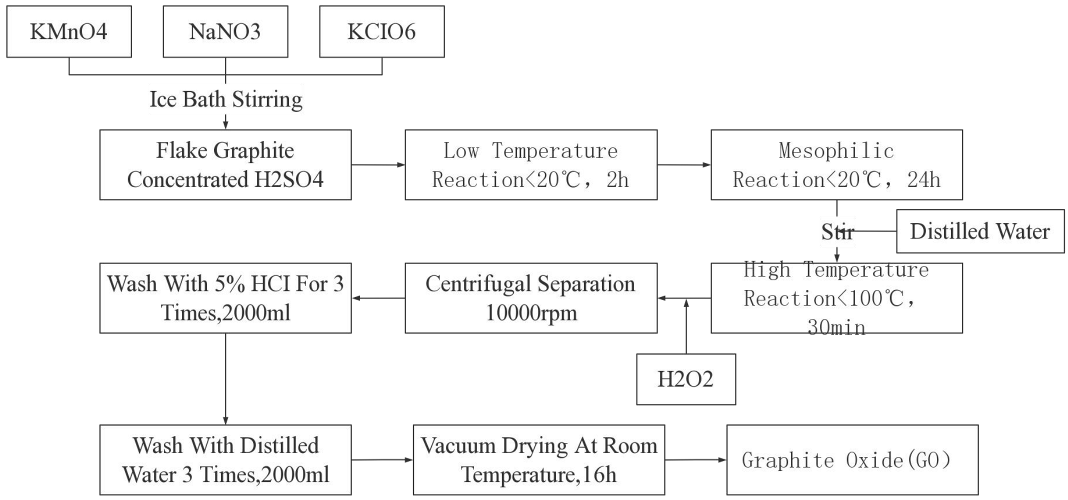

Figure 2 Graphene development using Hummers method

2.2 Preparation Materials

Fe3O4 and GO-Fe3O4 can be prepared by hydrothermal method in high pressure reaction. The detailed process is shown in Figure 3 below. In order to further study the application functions of GO, Fe3O4 and RGO-Fe3O4 in electromagnetic shielding and their influence on the composition of cement shielding effect, cement paste should be added in different proportions to make composite materials.[7.8]

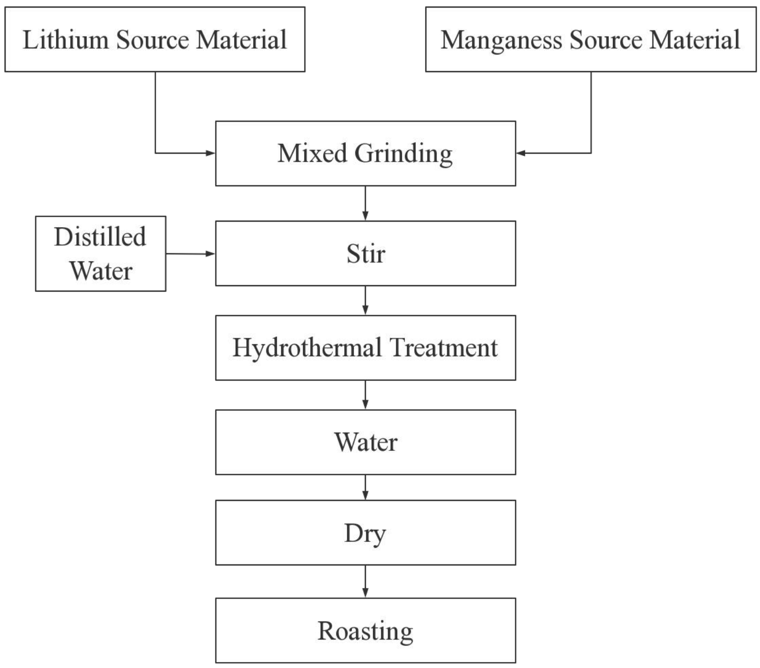

FIG. 3 Flow chart of hydrothermal method

2.3 Performance Test

In the experimental research process, the vector network analyzer and waveguide method are used to focus on detecting the electromagnetic parameters of the test samples in 8.2ghz to 12.4ghz frequency, and accurately calculate the shielding efficiency. Among them, the length of the sample can reach 22.6 mm, and the width can reach 10 mm. The S-2500 scanning electron microscope developed by Hitachi, Japan, is used to focus on the microscopic morphology of the section of the test sample. At the same time, according to GB/T17617-2007 "cement mortar strength test Method", comprehensive study of cement test sample compressive strength and flexural strength.

3. Result analysis

3.1 Experimental Results

On the one hand, the performance of electromagnetic shielding. Different GO doping amounts will have different effects on the shielding properties of cement and composite materials, where 1-8 represents the experimental results when the graphene solid doping amounts occupy 0%, 0.01%, 0.03%, 0.05%, 0.08%, 0.10%, 0.12%, and 0.15% of the cement mass, respectively. The final results show that when the amount of graphene solid doping reaches 0.03% and 0.08% of the cement mass, the electromagnetic shielding performance of cement-based composite can be optimized, and the shielding efficiency will gradually increase with the increasing frequency, which is higher than that of blank sample. When the quantity of graphene solid doping reaches 0.05%, 0.10% and 0.01% of cement quality, the electromagnetic shielding efficiency will continue to rise, and the low frequency band is lower than the blank sample, while the high frequency band is higher than the blank sample. However, when the doping quantity exceeds 0.10% of cement mass, the shielding efficiency will be lower than that of blank sample.[9.10]

In the influence of the quantity not allowed to be doped on the electromagnetic shielding properties of cement-based composites, 1-4 represents that the quantity of solid Fe3O4 doping occupies 0.03%, 0.07%, 0.10% and 0.12% of the cement quality, respectively. In each sample, the amount of graphene solid doping accounted for 0.05% of the cement mass. According to the curve change in the figure above, when the doping amount of solid Fe3O4 reaches 0.03%, the actual electromagnetic shielding performance is the highest, and when the frequency is gradually increasing, the electromagnetic shielding efficiency will gradually increase after a brief decline. When the doping amount of solid Fe3O4 reaches 0.07% and 0.10%, the shielding performance of cement-based composite is the lowest. At this time, nano-Fe3O4 cannot evenly disperse cement paste.

The different doping quantities of 1%GO hybrid RGO-Fe3O4 will have a very deep impact on cement-based composites, in which the experimental samples represent that the doping quantities occupy 0%, 0.01%, 0.03% and 0.05% of the cement quality, respectively. According to the trend of the curve, the electromagnetic shielding performance of cement-based composites will be improved with the continuous increase of the doping amount of solid RGO-Fe3O4. The optimum doping amount is 0.05%, which increases by 20.2% on average in the low-frequency region and 33.4% on average in the high-level region. Since graphene itself has a special two-dimensional sheet structure, which can promote electromagnetic wave absorption, RGO-Fe3O4 formed by iron oxidation supported by matrix has the following advantages: first, graphene has high thermal and electrical conductivity, and its overall weight is light, which is helpful for electromagnetic wave absorption and attenuation; Second, the application of ferrite particles can improve the ferromagnetism of graphene, so that cement-based composites have electrical and magnetic losses, which is helpful to complete electromagnetic matching. Third, the reflectance loss of ferrite is usually in the low frequency range, while the reflectance loss of graphite is usually in the high frequency region, so the combination of the two materials can continue to extend the frequency band. The preparation flow chart of graphite material is shown in Figure 4 below:

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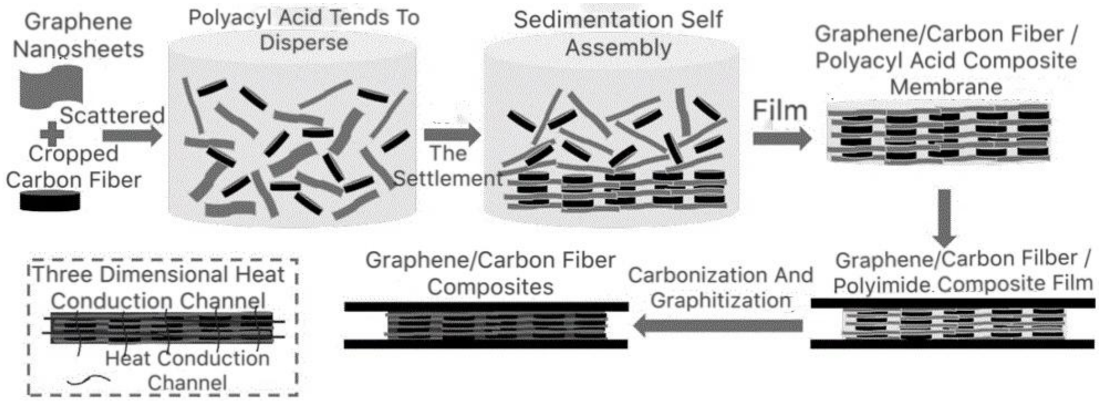

FIG. 4 Preparation flow chart of graphite material

Hydration, on the other hand, affects. According to the analysis of cement industry operation flow chart shown in FIG. 5 below, the test sample of cement slurry after hydration for seven days was obtained under standard conditions. After vacuum drying for one hour, the section of this material was analyzed by experiment. The final results show that after seven days of water treatment for the cement paste samples without graphene doping, the hydration products mainly take ettringite in the shape of real rod and calcium hydroxide in the shape of hexagonal plate as the core, and the overall structure design is very loose.

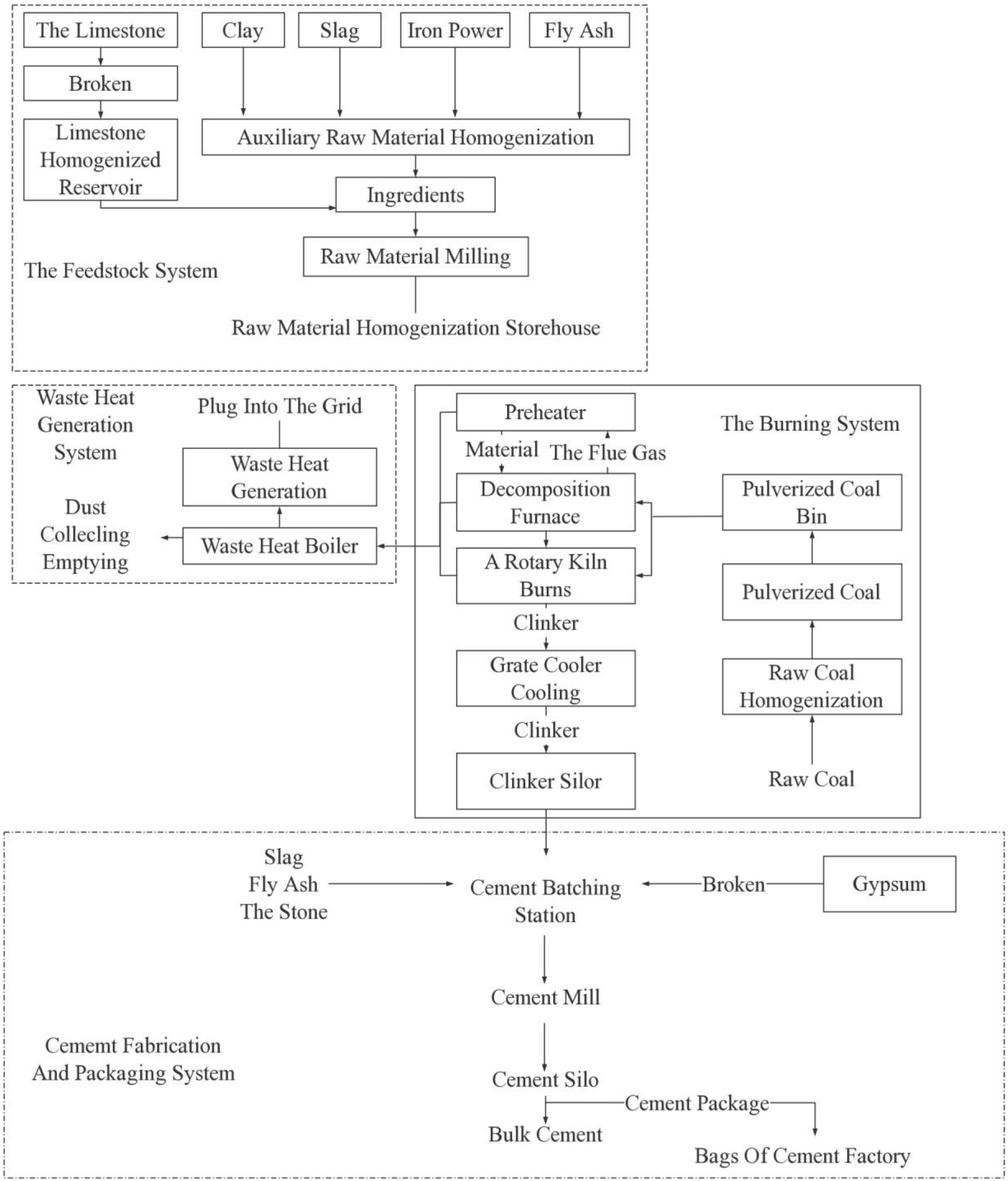

FIG. 5 Operation flow chart of cement industry

By observing the section of hardened cement doped with 0.05% graphene after 14 days, it is found that the hydration products of cement are mainly rod-like ettringite, hexagonal plate like calcium hydroxide, and flocculent C-S-H gel. The shape of the products is regular, and the morphology and structure of the sections are very close. At the same time, the hydration products of cement appear flower-like crystals, which have a growth point, and these flower-like crystal products are produced in one piece, so it is easy to form crystal clusters. The reason for this phenomenon is that graphene has a large number of active groups, which can excite and promote cement hydration reaction, and can also provide an effective template for the formation of crystal products of hydration reaction. In addition, the construction of flower-like crystals with tight structure and neat arrangement provides an effective basis for improving the strength of cement-based composites. Therefore, it is the main issue discussed by researchers at present.

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4. Conclusion

In conclusion, RGO-Fe3O4 has a great impact on the electromagnetic shielding performance of cement-based composites, which proves that the active group of GO acts as a template in the hydration process of cement and mainly affects the early hydration reaction. Therefore, Chinese scholars should continue to explore how to use graphene in the new era and improve the application strength of cement-based composites according to the basic theories and practical achievements of graphene and cement-based composites, so as to truly meet the fundamental needs of technological exploration in various fields in the new era. At the same time, to strengthen the training of professional and technical personnel, from the Angle of sustainable theory and technological research, and actively introduce advanced research results and practical experience, software and use the advanced modern information technology, build standard security research environment, only in this way can fully show the application of graphene and cement base composite material value, This paper provides an effective basis for modern material technology application in China.

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