Expanded graphite / Polyaniline / F & O4 Composite

Preparation and wave absorbing property

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Abstract: expanded graphite was prepared by in-situ polymerization method / Polyaniline (Eg/pani Composites, will Fe3 0 + is loaded on Eg/pani Surface,
to obtain a with electromagnetic absorption properties Eg/pani/fe3 0 4 Composite. by scanning the electron microscope (SEM), X X-ray diffraction (XRD),
Fourier Transform infrared spectrometer (FTIR) and Vector Network Analyzer (VNA the appearance of composite materials, the component and absorbing properties are studied investigate. The Wave-absorbing performance analysis results show that, When the doping concentration is 0.05 mol/l, Match thickness d = 2 mm, Minimum reflection loss for samples (rl_
in 8. $ GHz at the - Panax DB. increases with doping concentration, Minimum reflection loss peak moves to low frequency, The corresponding thickness of the is gradually thickened. Dielectric Relaxation polarization of the material, Eddy Current loss and A/4 Interference cancellation of the model Shuangfeng, makes the Eg/pani/fe3 0 4 Composite in electrical The field of magnetic wave absorption has certain application prospects.

Keywords: expanded graphite; Conductive Polymers; Magnetic Material; Composite; Wave-absorbing performance diagram category number O633.5; TM25 document marker A

with the wide application of electronic products, Electromagnetic Interference, electromagnetic pollution and electromagnetic leaks are getting worse, prepare for civilian and military purposes subject to concern. and a absorbing material is a functional material that is consumed by converting electromagnetic waves projected onto its surface into heat or other energy. Composite absorbing material can effectively improve the electromagnetic environment, reduce electromagnetic leaks, is a new functional material ∧.

ferrite as a traditional nano-absorbing material, has super paramagnetic and nano effects, absorbs performance strongly, The has in the field of electromagnetic absorption Wider application. But its disadvantages such as high density and easy oxidation limit its application. Polyaniline (PANI) is a good stability, raw Materialcheap, synthetic Easy, conjugated conductive polymers for high temperature and antioxidant properties, The has in the field of electromagnetic absorption. The applied price set by value. The composites of both have a great concern because of their electrical losses and magnetic losses. Hou etc.10 using hard template method to prepare hollow structure F &O4/pani Minimum reflection loss for microspheres (RLm in ) on GHz at -24.3 DB. Guo Yajun [7] The prepared the polyaniline / F & O4 / Carbon black composites, to C band (4–8 GHz) and Ku band (12–18 GHz) has better absorption of electromagnetic waves. and carbon black than, worm-shaped expanded graphite (EG) as a new type of carbon absorber, due to porous network holes, to have a larger area than the table, to produce a high activity fresh surface, and an increase
in the interface layer will generate multiple layers of reflection on electromagnetic waves or Absorbs the, and to 
Increase the wave-absorbing ability. Zhao etc. prepared eg/f&O4Nano-ring, its m in in 6. 8 GHz at -24. 8 DB. Chen ,
and so on prepared EG / Pani/cofe 2 0 4 Composite, its RLm in in 13.28 GHz at -19. DB. for this, will F &O4 load 
on eg/panimatrix. Get loose porous structure ternary composite material, is expected to improve the electromagnetic 
matching effect of materials, from the To improve its wave absorbing performance.

This article uses the in-situ growth method to prepare the Eg/pani Composite, and Fe ; O 4 to Eg/pani Composite
for adsorption, gets the with both electrical loss performance and magnetic loss performance. / pani/fe3O4 composite, 
and study different HCl Doping to EG/ pani/fe -> Effects of absorbing properties of composite materials,prepared by EG
/ pani/fe -> Composite has a certain wave-absorbing performance, good wave performance. 


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1. Experiment Section

1.1 Reagents and instruments

aniline ( An ), Parse Pure , Tianjin da Mao chemical reagent factory, use after decompression distillation ;
ammonium persulfate ( APS ), Parse Pure , Tianjin City Heng Xing Chemical Reagent Manufacturing Co., Ltd. seven
hydrated ferrous sulfate (FeS 0 4*7 H2 0 ), Parse Pure , Tianjin da Mao chemical reagent factory ; six hydrate ferric
chloride(FeCl3 *6 H2 0 ), Parse Pure, Yantai Chemical Co., Ltd. ; Ammonia ( Quality Score 25%-28%, parsing Pure ,
Silver Companion Chemical Reagent Co., Ltd. ; Hydrochloric acid (HCl, Quality Score 36%-38%, Parse Pure , Silver
Companion chemical Reagent Limited companies; anhydrous ethanol, Parse Pure , Tianjin Fu Yu Fine Chemical Co.,
Ltd. ;expanded graphite ( EG ), Excellent-level pure, Qingdao Tian Yuan da graphite Co., Ltd. ; two times distilled
water for homemade .

S -4800 Type field emission scanning electron microscope ( SEM ); Japan Hitachi Corporation ;D 8/advance type
X x-ray diffraction (XRD) instrument, German Brooks company ; NEXUS-670 type Fourier transform IR spectrum
( FTIR ) instrument, USA Hi-Power company ; PNA . 5244 A type vector Amount Network analyzer, agilent .

Eg/pani Preparation of composite materials

references [A] method to prepare the Eg/pani Composite . will 0. G [] [] to join ? ML The ultrasonic dispersion in
distilled water is complete all, join 0.40 mol/l Hydrochloric acid and 0.50 ML aniline , Ultrasonic Scatter complete .
Transfer the system to three bottles, will again contain the 1. g APS "" ML Water Solution constant pressure 0. 5 h Add
to above solution, Magnetic Stirring H , centrifugal Drying , To get eg/pani composites .

Keep the amount of expanded graphite constant, The amount of other reagents is increased proportionally to
( Table 1 ), Repeat the above experiment as a control experiment .

eg/pani/fe3O4 Preparation of composite materials

references ] method to prepare the Fe 3 0 4 Magnetic nanoparticles . adds a certain amount of FeS 0 4 7 H 2 0 and
FeCl3 • 6H2O massage ratio for 1: 2 blending, and dissolving it to 100 mL in distilled water ultrasonic disperse evenly .
Transfer the mixture to three bottles, under protection Water bath heating to 0 ° C . Add ammonia reaction 2 H after ,
heats up to ° C And keep the warm 1 H . washed, gets after drying Fe3 0 4 Magnetic Nano granule .

will 4-Ani-3 Composite and 0. G Fe3 0 4 magnetic nanoparticles added to ML anhydrous Ethanol , Ultrasonic
Dispersion completely, transfer to three-port bottle mechanical stirring 3 H, Magnetic Separation, Dry, gets the EG /
PANI / Fe3 0 4 Composites .

2. Results and discussions

2.1 Sample Characterization

2 | Composite Materials Research
diagram 1 Scanning electron microscope photos for different materials. From Diagram 1 (A) to see, EG renders a loosely porous structure, with a good slice layer structure. The that is prepared in this article EG Good expansion, has a fresh, active surface, is PANI The in-situ growth of provides the basis for. diagram 1 (B) ~ (E) is different PANI Packet-covered EG / PANI sem photos of composite materials. diagram 1 (B) The amount of aniline is 0.50 mL. """" EG / PANI Composite Shape, to see, PANI in the EG Block reunion on, and accompanies PANI Fiber-like aggregates. diagram 1 (C), when the amount of aniline is reduced to 0.25 ML, PANI The package for is larger than the figure 1 (A) is noticeably smaller, but still has PANI particle reunion in EG Surface. further reduce the amount of aniline to 0. ML, from Diagram 1 (D) to see the clearly PANI Evenly to overwrite EG layer Structure, with better wrapping effect. also, from Diagram 1 (G) EDS The spectrogram can see, There are in composite materials N, Cl and Selment, where Cl The element originates from the HCl doped, S The element comes from an oxidizer ammonium persulfate, proved to be covered in expanded graphite surface particles to PANI M when the amount of aniline is lowered to the 0. ten mL when, from Diagram 1 (E) to see, PANI still enable EG End full cover, But the amount of coating is significantly higher than that of aniline 0. ML less. in the EG / PANI Composite Load Fe3O4 Experiment, uses aniline for 0. ML.

diagram 4 gives the EG, PANI, Fe3O4, EG / PANI and EG / panife3O4 Composite TGA Curve. when the temperature reaches All °C, EG and Fe3O4 The has a lower rate of weightlessness, is 8. 3% and 8. 5, and PANI The weight loss rate for is upward to 17%. PANI weightlessness of can be attributed to 3 phases: adsorption of water loss and reaction of aniline monomer volatilization, The volatilization of low polymers and the decomposition of polymer molecular chains. EG / PANI Composite in All C The weightlessness rate for is 28%, to calculate the in the composite PANI The mass fraction of is approximately 45.4%, is lower than the composite in PANI The theoretical content of, This is because the PANI and EG There is an interaction between, Enhanced composite material Material Thermal stability. ternary EG / panife3O4 The final content of the composite is 81.0%, to calculate the in the composite Fe3O4 has a mass score of + 1, slightly Lower Fe3O4 Add amount 50%.

2.2 Electromagnetic Wave absorption performance analysis

takes into account the HCl Doping amount to PANI Electrical Performance Impact, with 0, 0. , 0. Ten and 0. i mol/L for HCl to PANI to mix Miscellaneous, get corresponding EG / Pani/fe3O4 Composites, samples are recorded as S 1, S 2, S 3 and S 4. combine composites with paraffin wax by quality more than 1: 1 Mix, and then suppress the mixed sample to the inside diameter 3. mm, , outside diameter is 7. mm, thickness is 2. a mm coaxial ring, on 2~18 GHz The frequency range tests its absorption performance for electromagnetic waves.

diagram 5 gives the 2~18 GHz Range Samples S 1, S 2, S 3 and S 4 The electromagnetic parameters of the. from Diagram 5 (A) to see, Sample S 1 ‘s Duplicate permittivity Real part U’) The value is much larger than the other 3 Sample, from The decrements to 5. with HCl An increase in the amount of doping, ꔙ value decreases, and each sample, values decrease as frequency increases, s2, s 3 and s 5 lower rate of is smaller. same, in Figure 5 (B), Sample S 1 for complex permittivity imaginary part U”) The value is also larger than the other 3 Sample, from the 5 Decrease to [ ] 6 With a larger trend, S 2, S 3 and S 4 for, The value is 9~5.46, 5.2~3 and 4.2~3 1, shows a trend of decreasing first and then increasing for the entire frequency range. diagram 5 (C), - like product S1 Complex permeability of (T) The change in is significantly different from the other 3Sample, in 2~10 and 15~18 GHz Is in a downward trend, in 10~15 GHz The scope is an increasing trend, and sample S 2, S 3 and S 4 for ꔙ The value is in the 6. 5 and ten. 5GHz minimum appears near is as the same as the maximum and the trend is similar. diagram 5 (D) shows the complex permeability of the sample ( ꔙ ) with frequency change relationship. Sample S 2, S 3 and S 4 a downward trend throughout the frequency range, and sample S 1 decreases before increasing, in GHz minimum value near, and 4Sample, ꔙ values have varying degrees of negative. A positive part of the value is used to reflect the loss of magnetic energy. Conversely, ꔙ The value is a negative representation of the magnetic energy from EG / PANI / Fe ^ radiation out of composites. The energy emitted by the may be caused by the motion of the charge under alternating. Root According to Maxwell's equation, The carrier in an alternating magnetic field forms a vortex current under the influence of a inductive electric field, and produce an opposite inductive power Farm, convert partial electric field to
magnetic field to radiate from inside material, cause value to drop negative $0.2324$.

Based on the transmission line theory, reflection loss of a single layer absorbing coating at the time of vertical incidence of electromagnetic waves (RL) can be emulated with the following model.

Diagram 6 gives the $\text{EG} / \text{PANI} / \text{Fe} 3 0 4$ Reflective loss curves for different thicknesses of composites. Contrast Chart 6 to see, when the matching thickness is 1 mm, Sample S 1 Minimum reflection loss for $\text{RL}_{\text{min}}$ on, GHz at -9. 4 DB; Sample S 2 in $D = 2 \text{ mm}$ in 8. $S \text{ GHz}$ Place $\text{RL}_{\text{min}}$ reaches -37 DB, corresponds to RL $< -10 \text{ DB}$ The frequency width of the is 1. $\text{GHz} \ (7.92 - 9. \text{ GHz})$; Sample S 3 at the matching thickness $d = 4 \text{ mm}$ on 4. A $\text{GHz}$ Place $\text{RL}_{\text{min}}$ reached -30. 8 DB, Bandwidth is 1. $\text{GHz} \ (4.24 - 5. \text{ GHz})$; same, Sample S 4 on Match thickness $d = 4.5 \text{ mm}$ on 4.24 $\text{GHz}$ Place $\text{RL}_{\text{min}}$ reach -40 DB, bandwidth to 0.96 $\text{GHz}(3.76 - 7.72 \text{ GHz})$, contrast 4 Sample Discovery, with HC 1 An increase in the amount of doping, the minimum reflection loss peaks of the sample are gradually moving to the low-frequency. Considering the reflection loss of the sample consumption and matching thickness, This article with S2 as example, comparison 4 sample RL $< -10 \text{ dB}$ Bandwidth. at the matching thickness $D = 1.5 \text{ mm}$, Sample s1,s 2, S 3 and The bandwidth for the 4 S corresponds to 0.24 64~. GHz, 1.92 $(- + 4 \text{ GHz})$ and 2. (12.72 - 14.8GHz). to discover, by adjusting the HCI The doping amount of, to make the $\text{EG} / \text{PANI} / \text{Fe} 3 0 4$ Composite to different frequencies The electromagnetic waves of the section are absorbed in varying degrees.

When the electromagnetic wave hits the surface of the material, will not only encounter reflection on the surface of the absorbing material, and will also encounter an anti-on the metal substrate fire, on the 2 The same frequency of reflection waves, if 2 Wave path difference for reflection wave (4) for odd multiples of half wavelength will appear dry.

When the electromagnetic wave enters the absorbing material, its wavelength $\lambda$ represents the with the following expression:

$$\lambda = \frac{c}{f}$$

with $S$ is the research object, Chart 7 the gives its minimum counter fire-loss peaks corresponding to $A / 4$ Model. to see, when match thickness 3.0, 3.5,4. 0, 4.5 and 5.0 mm when.

A appears under the same matching thickness 2 feature absorption peaks (divide To be 5., 6 GHz 72.15 GHz;

4. a GHz; 3.52, 11.44 GHz; 3.

10.32 GHz), and with increased matching thickness, Shuangfeng The band width between decreases gradually. Description $\text{EG} / \text{PANI} / \text{Fe} 3 0 4$ The electromagnetic absorber at the minimum reflection loss peak of the composite material $A / 4$ and 3 $A / 4$ Model. The main reason for is that the absorbing material The reflection waves on the surface and the reflection waves of the matrix are eliminated. . indicates that interference is eliminated in $\text{EG} / \text{PANI} / \text{FeSO} ^ 4$

Composites The Electromagnetic absorption process of the plays a significant role in.

Electrical loss tangent ($\varepsilon^\prime$) and magnetic loss tangent ($\mu^\prime$) reflects the electrical loss energy of the material to the electromagnetic wave Force and magnetic loss Ability $0.239$. From Diagram 8 to see, with $\text{EG} / \text{PANI} / \text{Fe} 3 0 4$ Composites HCI increases the amount of doping, The electrical of the material The loss tangent values are decreasing, and their magnetic loss tangent values are increasing. and the electrical loss tangent value ($> 0$) throughout the frequency The rate range is greater than the magnetic loss angle tangent ($< 0$), description power loss in $\text{EG} / \text{PANI} / \text{Fe} 3 0 4$ composites absorbing electromagnetic waves The contribution of the process is greater than the loss of the magnet. The reason for the electrical loss caused by IS: (1) $\text{EG} / \text{PANI}$ Electronic jumps on the surface, To form a conductance $10^6$ to; (2) A conductive network may be formed inside a composite material, causing electrical loss $M$.

to study dielectric loss and magnetic loss of materials, Many scholars introduce Cole $^4$ Cole semicircle and Co $^4$' k $^2$. Corps $^4$ theory $^4$ Sample S 1 as an example, by Diagram 9 (A) can be seen in the, is in the 30-45 Scope, $\varepsilon^\prime$ is in the 14-23 in the range, $\text{EG} / \text{pani/fe} 3 0 4$ The Composite has a cole$^4$cole semicircle. because of its, and, value decreases with frequency increase, can be inferred from the 10-18 GHz appears in the scope of cole$^4$cole semicircle, The indicates that the material has dielectric relaxation in the High-frequency range, The is primarily made up of dipole polarization and interface poles cause ’38. is usually, Magnetic losses are mainly derived from domain wall
resonances, Eddy Current loss, Natural resonance and exchange resonance on, and Domain wall resonance on 2–18 GHz Band is negligible. The Magnetic loss of the sample may be caused by an exchange resonance, This is because the F & O4 The ruler of the nanoparticles in ten nm around, Small particle size, is advantageous for resonance exchange behavior. From Diagram 9 (B) To See, for the material C 0 value is gradually with frequency Decrease, on 8 GHz Basic remain constant, This description E(pani/ FeO#) The absorption of electromagnetic waves by composite materials in the 8 GHz Natural resonance in range, 8 GHz within range of Eddy current loss main.

3. knot theory

the uses the in-place aggregation method to prepare the E(pani composite, and Fe3 O4 to E(pani composite material adsorbed, gets the with electromagnetic performance E(pani/ pani/fe 3 0 4 Composite, and pass HC 1 to modify the. Research Discovery, Low Doping concentration Benefits The material's absorption of electromagnetic waves. When the doping concentration is 0. mol/l, Match thickness D = 2 mm, in 8, 5 GHz at RLmin to reach -37 DB increases with doping concentration, The frequency of the minimum reflection loss peaks of the sample decreases when it appears (64–4.24 GHz), match thickness gradually thicken (1–4.5 mm), by adjusting the HCl Doping concentration, to effectively adjust the frequency bands of the best absorption peaks. The results of the composite electromagnetic parameters indicate that, electrical losses contribute significantly to the electromagnetic absorption process. The material has a dielectric in the High-frequency range yu phenomenon, and 2–8 GHz The magnetic losses of materials within the range are mainly natural resonances in 8–18 GHz Eddy Current loss in scope is the primary above loss and A/4 Shuangfeng of interference cancellation in the model, makes the E(pani/fe 3 0 4 Composite Pairs in 2–18 GHz Scope Partial band electromagnetic shielding within has Application Prospects for.

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