Performance and decomposition behavior of hydromagnesite Mg (OH)2 Synergistic polyethylene flame Retardant composites

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Abstract: TheFlame retardancy polyethylene (PE) matrix composites were prepared by twin-screw extruder, WithHydromagnesite (HM) and Mg (OH)2As the flame retardant. The flame retardant properties and mechanism ofHM,Mg (OH)2/pe Flame retardant composites were investigated by limited oxygen index (LOI), Vertical buring Test (UL-94), Cone calorimetric Test (CCT) and universal tensile test. The thermal decomposition behavior of HM-MG (OH)2/pe flame Retardant Composites was studied by Thermogravimetric analysis (TGA). The results Show thisis, the flame retardant in appropriate proportionsofhmandMg (OH)2decomposes in The combustion tempera-ture range which leads to a better flame. In the premise of the same LOI and tensile strength, the cost of PE Composite with synergistic flame retardant decreases significantly with Mg (OH)2 as flame retardant alone. The ineffective even negative decomposition of HM reduces the synergistic flame, and the Inhibi Tory effect on the decomposition by the PE matrix with HM under high temperature is retained. At the same time, a Hejunjie, CHENG Yu,ZHANG Xin,et al performance and decomposition behavior of HYDROMAGNESITE-MG (OH)2 synergistic polyethylene flame retardant composites[j]. Acta materiae Compositae sinica,2017,(a):2674-2680 (in Chinese).

Relatively stable scaly protective 1ayer Forms in the combustion region surface, in addition, the total lost mass of SYNEr The synergistic Flame Composite is higher. With those variety of factors, the flame retardancy effect of the synergistic flame Composite is higher. The HM-MG (OH)2/pe flame retardant Composites pass the UL-94 Vb13>-0rating with LOI valueof28%, and the tensile strength reaches 8mpawhen mass ratio of HM to Mg (OH<b20>) 2is1:2 with 60wt% loading.

Keywords: hydromagnesite; Mg (OH); synergistic flame retardant; Composites; Cone calorimetric

Brucite (hydromagnesite, HM) is a magnesium Minerals, The main ingredient of the is hydrated alkali magnesium carbonate. HMmineral pluswork Simple. In recent yearsthe application of HMis increasing, main[to apply domain for preparation of Magnesia, Basic Magnesium carbonate, etc., additionally report pointo, HM has a wide application in the field of fire-retardant foreground[1-3].

HMThe fire-retardant mechanism of andMg (OH)2 similar[4,5], HM the ability to release water and under thermal actionCO2, these decompositionrelease process can absorb a lot of heat, to reduce flame retardant polymers material surface flame temperature, Delaying its degradation or making it difficult to burn; same When the water vapor and CO2 can override Flames, Burn down area combustible gas and oxygen concentrations; also decompose remaining Mg (OH)2 and MgOetc can be on polymer surface to form a heat transfer barrier layer, block continuation of polymer matrixso-

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But related research also indicates that, HM flame Retardant less efficient, and high proportion of HM bound to
cause polymer materialsthe mechanical properties of the material drop significantly\(^{8,9}\).

HM fire Retardant as a flame retardant is relatively low, is large level is due to HM decomposition temperature is too low cause of, can take the Mg (OH) vs HM duplicate, use the HM-Mg (OH) Composite blocking The Synergy in the decomposition of the fuel agent, get lower cost, performance is more OKHM-Mg (OH) co-polyethylene (PE) Flame Retardant composite.

1. Experimental materials and methods

1.1 Raw Material

HM, size Di Ten’ m, Jiangsu Sibeli new material has Limited Company; polyethylene, \( \text{(8)s} \), Lanzhou Petrochemical; Mg (offi2) granularity $ to [*] 5 jum, Shandong Dongying Ocean Chemical Co., Ltd.

1.2 hm-mg (OH)\(_2\) Collaboration P Preparation of flame retardant composites

will HM and Mg (OH) follows the table1 proportional to with mix evenly in high speed mixer and sift, made HM-Mg (OH) Composite flame retardant.

Double screw extruder (haake poly labOS, beauty Thermo Fisher Technology Co., Ltd.) Preparation of flame retardant quality fractionsto $\text{wt\% and}\ W/T\% Fire-retardant for PE Composite, Extrusion temperature degrees 165 ~ 175°C, rotate Speedr/min. with Huck mininjection molding machine (haakeminijet, United States Thermo Fisher Technology public Division on 175°C, % MPa injection molded into standard test under injection pressurespline.

tests and representations

thermogravimetric analysis (Thermal gravimetric analysis, TGA): take approx5–10 mm samples, with Netzsch TG 209 F1 Hot-weight Analyzer, with 10°C/min. The speed of the is from room temperature Uptoi-C, to test the thermal weightlessness of the sample in an air atmosphere behavior.

Limit Oxygen index: Follow the GB/t12406 2-2009\(^{[1]}\). Enterline, Using Oxygen Index Analyzer (HC-2 type, Nanjing Jiangning District, Instrument factory) test specimen limit Oxygen index.

Vertical Combustion: Follow the GB/t2048-2008\(^{[2,3]}\), mining with vertical combustion tester (czf-3 type, Nanjing Jiangning District Analysis Instrument factory) test specimen vertical combustion performance.

eXtrude performance: Follow the GB/t1040.1-2006\(^{[4]}\), on, using Universal Mechanics test machine (CMT 5504 type, Thinktwice about Shenzhen Material Test Co., Ltd. test specimen tensile Properties.

Conecalorimeter: Reference: ISO56601\(^{[5]}\), sample size SMMC + MMX3 mm, Thermal radiation intensity is KW/m\(^2\), using conecalorimeter (FTT, United Kingdom Tensilica (G)) test-try like burning behavior.

2. Results and discussions

2.1 HM-Mgo(h) decomposition behavior of composite flame retardants

diagram1 is HM, Mg (OH) and HM-Mg (OH) Complex Heat-heavy curve of flame retardant in air. from Diagram1 (a) can see out, Two inorganic compounds have a significant weightlessness in the heating process, where Mg (OH) in 305 ~ 421C concentration weightlessness between: 4 and HM The thermal weightlessness of is mainly divided into three stages: in 191 ~ 352C weightlessness 2%, in the 352 ~ 492C weightlessness 33% in 492 ~ C weightlessness 46%, when 8 \( \text{HM weightlessness Total compared to Mg(OH)High8, Visible HM as fire retardant not only releases more flammability during combustion} \)

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\text{diagram1 Brucite (HM), M}_{2}(\text{OH}) \text{2} (\text{a}) \text{and brucite-Mg (0id2 Composite}}
\]

Flame Retardant (b) Hot-weight curves for (warming rate 10°C/min, room temperature ~800°C, Air)

Fig.1 Thermal Gravimetric analysis Curves of Hydromagnesite

(HM), MG (OH) 2 (a) and NM mg (on) 2 synergistic flame Retardant (b) 10°C/min, room temperature-800°C, Air)
gas to suppress the occurrence of combustion, and the temperature range of the effect is more wide. But HM start decomposition temperature low, 191~352°C interval. Structural water released within is easy to create as a polymer flame retardant. Chengkai Body Foaming, but may increase polymer contact with air. Area, accelerating burn occurrence.[5], and HM in 352~492°C. The primary decomposition of the is that the decomposition release is higher than the HM, but divided by solution. Temperature comparison Mg(OH) slightly higher, its flame retardant validity may be affected by to affect. To improve. The fire-retardant effects of the HM, can be HM with Mg(OH) Duplicate. To adjust the composite flame retardant by mixing proportions decomposition features, play a synergistic effect.

From Diagram 1 (b) to see, decomposition behavior of complex flame retardants combined with HM and Mg(OH) Decomposition characteristics of two components, Subdo not 190 ~ 310°C, 310 ~ 425°C. The primary decomposition of the is to increase the inhibition. HM blocking, burns, Increasing composite material quality 9%, This decomposition process is in the suppression matrix. The effect of material combustion is limited, actually compositematerial Weightlessness in this phase is higher than in composites HM theory. Weightlessness 792%, [7], may be due to HM decomposition causes composite in PE contact Air interface promotes decomposition, on 385~425°C scope, HM blocking burn composites HM start decomposition, and on the decomposition level End of paragraph, composite decomposition release rate compared to this phase peak

400°C temperature "C diagram 2 Brucite-mg (OH) 2 synergistic polyethylene flame retardant composites

Thermal weightlessness curve warming rate 10°C/min, room temperature ~ 800°C, (Air)

Fig. 2 Thermal Gravimetric analysis Curves of hydromagnesite-Mg(OH) 2 Synergistic Flame Retardant polyethylene composites (10°C/min, room temperature -800°C, (Air)

value dropped significantly, in 425°C decreases the thermal weightlessness rate of composite to 0/min3, and then go to the PE break main decomposition speed up phase, and Composite in PE explode peak value temperature comparison Mg(OH) 2 flame retardant composite improved 10°C, visible, HM in addition to being able to produce difficult gas by blocking combustion occurring outside, its decomposition phased product to PE the decomposition of can also take the inhibition[5], compared to HM Fire retardant PE composite, HM1 MH1 Co- PE flame retardant Composites in 191~352°C. Zero weight loss between only 6.4%, also divided by after the flame retardant has been decomposed interpretation drop rate significantly decrease, PE Peak decomposition temperature of in Step increase reach 462°C. Visible HM + Mg(OH) with goodsynergistic flame Retardant, to reduce composite at low temperature area invalid decomposition, can also be retained HM decomposition products to PE decompose inhibition.
2.3 HM-Mg (OH)_2Collaboration PE Flame Retardant composite heat releaserate

diagram3isHM-Mg (OH)Collaboration PE flame Retardant compositeHM,MH, HM1MH1and PE hot-release in cone calorimetrydrop rate (Heatrelease Rate, HRR) and Total heat release (total heat release, THR) over time curve, tablethe 2is the corresponding data for the cone thermal curve combined with a chart to secout, add flame retardant composites compared to pure PE up 548.3 kW/m² The peak heat release rate is significantly lower for where, HM flame retardant PE composites with Mg (OH) PE flame retardant PE compound Materiala Maximum hot release rate pkhrr1 (Peak Heat release rate) are allik W/m². Around, but HM flame retardant PE Peak heat release of composite material appears earlier, its lighting time (time ignition, TTI) only 3s, compared to pure PE is smore advanced. This may be due to a cone calorimeter test with a inHM start decomposition at lower temperature, Explode release gases causes PE Matrix Foaming Volume expansion, Expansive materials The surface is exposed earlier. The spark ignition device of the cone calorimeter from theis lit. [1] /pure PE due to low temperature decomposition gas less, anti-and TTI longer. Mg (OH) flame retardant composites TTI long upto 5. This may be the same as Mg (OH) The low temperature stability of hasclosed. HM1MH1 Composite Fire retardant PE Composite due to HM contains less, burn time compared to HM flame retardant composites extended to Tens, and its KHRR1 is only A 5. KW/m², for several duplicatematerial lowest. Mg (OH) flame retardant PE Thermal release of composites The curve is more like a top-leaning trapezoid, Its second largest hot release rate peak PKHRR2 (Peak Heat release Rate) not obvious, HM flame retardant composites and HM1MH1 Fire retardant PE Composite HRR The curve is similarto M Shape, reference The in the hot-weight test

A reduction in the rate of weightlessness of composite materials after the decomposition of the flame retardants, MTHe heat release peaks may be generated by HMTThe decomposition product suppresses the PEThe results of matrix decomposition, both pkhrr2 are lower than theripkhr1, HM1MH1 Fire retardant PE Composite pkhrr2 more low, is only 113. 5kw/m². Compare the total amount of heat released by the to see, The addition of a flame retardant significantly reduces the total amount of heat released by the pre-3 (8) seconds material, where HM1MH1 Fire retardant PE Composite Minimum, is only 1mj/m², compared to pure PE 6mj/m² drastically reduces 1%, when irradiation, to reach 600s, flame retardant composites with pure PE the THR gap between is narrowing, This is mainly due to the flame retardant of inorganic flameretardant mechanism decision of, inorganic flame retardants are mainly produced by decomposition of nonflammable gases Suppression initial burn occurrence, But when inorganic decomposition complete after”“ , “inorganic oxides residual organic oxide high thermal conductivity, very, hard to form a good insulating layer [9], Therefore in the cone-heat continuous High radiation intensity, The combustible components in the final composite are decomposed burndown.

diagram4is three HM-Mg(-OH)_2 2 Collaboration PE Flame Retardant compositematerial cone weight thermal test sample photo visible, Test EndAfter most samples are white, almost no carbide generation, need Note, Mg (OH) PE flame Retardant composite cone calorimeter test the sample after forms a seemingly complete compact surface, but like Product Center has a huge collapse, Description of the production of dense surface noblock surface lower PE continued decomposition of the matrix combustion [7], with HM fire-Retardant PE Composite after test render loosely crushed table Face status, corresponds to the worst fire-retardant effect of the three . but broken The appearance of the surface may also indicate that HMdecomposition products and PEMatrix and the decomposition products form some kind of composite structure, This structure as aThe whole was destroyed by intense irradiation at the end of the cone heat test a. HM1MH1 Fire retardant PE Composite presented after test Scale-like surface structure with cracks, This structure is both inthe_Todegree To Maintain shape integrity, simultaneous sample deep decomposition production the Raw gas does not gather in the center, Causes a large surface of the protection layer product break, This could be HM1MH1 flame retardant PE composites for better performance in cone calorimeter test[29], also explains HM and Mg (OH) has good synergy in the flame retardant process Action.

2.4 HM-Mghj Co)PEmechanics of flame-retardant composites performance and flame
**retardant performance**

Table 3 is HM-Mg(OH) Collaboration PE flame retardant composite

HM, MH, HM1MH1 and PE limit Oxygen index for, Vertical burn performance and tensile strength data. Can see, add 50 wt% and 60 wt% flame retardant composites all have better fire retardant performance of, its vertical combustion performance is up to UL-94V-0 level, Mg(OH) and HM-Mg(OH) Collaboration PE flame retardant composite the Limit Oxygen Index of the material in the flame retardant content is 5 0 wdon’t [% * [*%]] reached 25%, compare to content HM Flare retardant PE Composite High, 2, compared to pure PE increases 8%, Mg(OH) and HM-Mg(OH) Collaboration PE the Limit Oxygen Index of flame retardant composites in flame retardant content? wt% is further enhanced to 28%, Phase Compare same content HM Fire Retardant PE Composite High 2, Compared to pure PE increases 11%.

Tensile strength display, add HM Fire retardant for PE Composites tensile strength compared to pure PE 3 MPabig drop, and Mg(OH) Fire retardant PE composite tensile strength compared to pure PE increases, to add the same amount of, HM1MH2 Fire retardant PE composite with Mg(OH) Fire Retardant PE Pull for composites Extended strength is basically the same, and the tensile strength of the composite fire retardants HM decreases gradually as the content increases. Overall considering mineral source HM compared to Mg(OH) cost, lower, one equal limit oxygen index and close tensile strength, with HM vs Mg(OH) flame retardant reducing the cost of flame-retardant materials. Good effect.

Table 3 Brucite-mg (OH); mechanical properties and limit oxygen index of polyethylene flame retardant composites

Table 3 mechanical properties and Oxygen index of HYDROMAGNESITE-MG (OH)2 synergistic flame retardant Polyethylene composites

### 3. Conclusion

(1) Brucite (HM) as a flame retardant although more flammable gases can be released to suppress burning of the fire in a burn through, but due to low initial decomposition temperature, on composite burn, the initial reaction will be counterproductive. will HM vs Mg (OH) reuse uses to decompose within a wider combustion temperature range to better flame retardant, is more than H M use flame retardant alone greatly increased, and in the Limit Oxygen index and tensile strength unchanged on premise, flame retardant polyethylene (PE) composite cost significantly down.

(2) When HM and Mg (OH) with a quality ratio of 1:2 Collaboration and the total quality of the composite is reached? wt% when, HM-Mg (OH) Collaboration PE the limit Oxygen index of flame retardant composites is 28%, vertical combustion level reaches UL-94V-0 level, tensile strength reaches 8 MPa.

(3) Although HM-Mg (OH) heat loss for composite flame retardant heavy behavior Performance HM and Mg (OH) individually decomposed plus and, but on HM-Mg(OH) co-fire retardant PE Composite, Two kinds of flame retardants show good synergy. HM and Mg (OH)2 synergistic Fire retardant mechanism: The composite flame retardant low H M the content causes the composite to ignite the initial invalid or even negative face decomposition reduction, But composite flame retardants can keep HM Decomposition Products against PE inhibition of matrix high temperature decomposition, can also burn burn surface to form more stable and less damaging scale like protection Layer, plus composite flame retardant overall higher total decomposition release rate, more factors work together, Improve the flame retardant effect of composites.

### References

