



Thermal stability and flame-retardant characteristic of irradiated LDPE and composites

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Abstract. Magnesium hydroxide (MH) and alumina trihydrate (ATH) are extensively consumed as fillers in polyolefins to fabricate naturally responsive cables. Halogen-free wires, and especially cross-linked or thermoplastic elastomers, are further prevalent in worldwide use. The limited oxygen index (LOI), cone calorimeter, smoke density and thermogravimetry (TGA) experiments explain the thermal decomposition, flame-retardant and physical characteristics of samples. Results from studies of TGA, smoke emission and LOI testers showed that the thermal strength and flame-retardant characteristics of the samples containing MH compared with corresponding specimens containing ATH have superior thermal stability. The flame-retardant and heat resistance characteristics of samples were improved due to irradiation and the development of cross-linking bonds in the polymer framework. The results of the smoke density experiment show that adding MH to low-density polyethylene (LDPE) results in the lowest smoke density associated with LDPE and LDPE/ATH compounds. This study proved that the inclusion of MH and irradiation of specimens caused a greater thermal strength and also a superior flame-retardant polymeric product compared with the inclusion of ATH to similar irradiated specimens. These successes are useful and appropriate specifically for cable companies to deliver halogen-free flame-retardant cable materials.

Keywords. Ignition; low-density polyethylene; cable; composite.

1. Introduction

In recent years, compared with other polymeric materials, low-density polyethylene (LDPE) has the major annual production. The reasons for global high demand of LDPE are the reasonable price, and individual physical and mechanical characteristics [1–3]. Therefore, the appropriate price of LDPE, accompanied by its significant mechanical characteristics, makes it a valuable preference for several types of cable insulations [4–6]. Ethylene vinyl acetate (EVA) is utilized generally in cable manufacture to fabricate heat shrinkage insulation, semi-conductive insulation jackets and anti-flammable insulation [7]. The wire industries utilize EVA as it permits extreme filler loadings and prevents embrittlement [8–11]. The wire manufacturers should produce wires with small smoke generation, acid/poisonous gas production and fire spread features along with the modern standards. Magnesium hydroxide (MH) and alumina trihydrate (ATH) are extensively consumed as fillers in polyolefins to fabricate naturally responsive cables [12]. Consequently, the demand for halogen-free cables and particularly the cross-linked or thermoplastic elastomers is turning out to be further common [13,14]. However, a large amount of metal

hydroxides is required to achieve appropriate flame-retardant characteristics, which causes a loss in the mechanical characteristics [15]. These hydroxides release water vapour, which eliminates fire hotness and minimizes flammable gases [16]. The combustion residues, metallic oxide layers (Al_2O_3 or MgO), shield polymer surfaces. These generated layers protect the polymer matrix from extra thermal breakdown [17,18]. Electron beam irradiation has been used to improve the insolubility, mechanical strength, rigidity and elasticity of polymers with potential applications and multiple applications. In addition, irradiation dose and irradiation duration are also two main factors influencing a polymer's degree of cross-linking. Further, the rate of irradiation dose alters the function of the cross-linked polymer. The growth of cross-linking bonds owing to electron beam irradiation improves the thermal strength (stability) of the irradiated polymer [19,20]. In this work, halogen-free flame-retardant (HFFR) specimens deteriorate *via* the combustion process and produce metallic oxides and steam. The ATH breakdown begins at 180–200°C. ATH breakdown is influenced by the particle size and the physical form of metallic fillers [21–23]. Water vapour discharge and thermal energy absorption ($1170\text{--}1300\text{ J g}^{-1}$) are associated with ATH thermal degradation [24–26]. MH also

thermally deteriorates like ATH by the same mechanism but at higher temperature (300–330°C) and higher energy consumption rate (1244 and 1450 J g⁻¹) [27]. The high breakdown temperature of MH makes it suitable for polymers requiring high temperatures in processing. The advantages of using ATH and MH as fire-retardant materials are as follows [28]:

- Polymer thermal breakdown is reduced by endothermic decomposition with hydroxide.
- Postponement of firing owing to evolution of water vapour, which dilutes flammable gas phase.
- The substrate is shielded from heat source owing to the formation of the impermeable layer of MgO and Al₂O₃.

HFFR cables are used in places where high standards of fire protections are required, such as high buildings, hotels, vehicle construction, underpass tunnels, road tunnels, telecommunication centres, industrial plants, power stations and so on [29]. There are some prior studies in this area, which identify the necessity of employing these types of investigations [30]. This study reveals the impact of ATH, MH and irradiation on the thermal stability and the flammability of LDPE/(ATH or MH) specimens specifically for cable fabrications.

2. Materials and methods

LDPE in the form of pellets of LH0075 category, a density of 0.921 g cm⁻³ and a melt flow index (MFI) of 0.89 g (10 min)⁻¹ was procured from the Bandar Imam Petrochemical Company (Iran). EVA with 18% vinyl acetate content, MFI of 1.83 g (10 min)⁻¹ and a density of 0.98 g cm⁻³ was procured from Elf-Atochem Company as pellets. ATH and MH of grade OL-104/LE and H-7, respectively, were procured from Martinswerk (Germany) for use in this research.

LDPE and LDPE blended with various additives (table 3) are melt-compounded in a twin-screw extruder model Brabender DSE-25. The length to diameter ratio (L/D) of the screw is 20 with temperature variations of 150–160°C. The specimens are warmed for 5 min; at that time, by compression, they are shaped into sheets in line with ASTM D-1928-96-2001 at 150°C under a pressure of 10 MPa for 3 min.

Irradiation takes place in air by means of a Cockroft Walton category electron beam accelerator (Nissin High Voltage) at an acceleration voltage of 3 MeV and 10 MA current. The irradiation dose in each pass is 50 kGy. Irradiation dose is in the range of 0–100 kGy.

Thermogravimetry (TGA) tests are run using a Shimadzu Analyser TGA-50 in the range of 0–1000°C. The TGA test is accomplished in a nitrogen environment, and the level of warming and scanning is 20°C min⁻¹.

The limited oxygen index (LOI) measurements are accomplished in line with ASTM D 2863.

A cone calorimeter tester was utilized to evaluate various ignition behaviours of LDPE/(ATH or MH) specimens. The

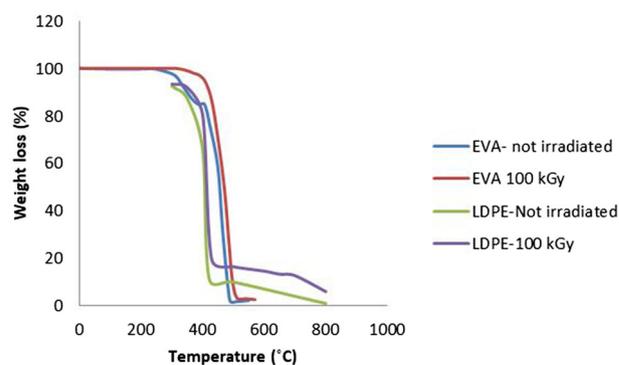


Figure 1. TGA outcomes of non-irradiated and irradiated LDPE and EVA.

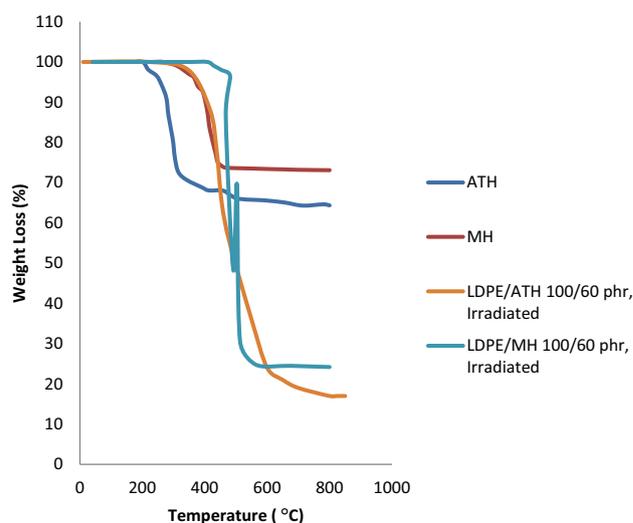


Figure 2. TGA outcomes of flame-retardant LDPE and composites.

cone calorimeter testing accomplished is consistent with ISO 5660 standard methods. Each specimen, with dimensions of 100 × 100 × 3 mm³, is packaged in aluminium foil and irradiated horizontally to an exterior heat flux of 35 kW m⁻².

Smoke emission characteristics are measured by in a smoke chamber compatible with the National Bureau of Standards (NBS) specifications in non-flaming settings (ASTM E662-03-2003), which offers a dynamic data of smoke intensity assessed by way of percentage transmittance ($T\%$) of light in place of the variable of time. The apparatus operated and intended for the assessment of smoke production is a Polymer Laboratories instrument System SN-2400.

3. Outcomes and analysis

Figures 1, 2 and table 1 display the weight loss alterations of ATH, MH, irradiated/non-irradiated LDPE, EVA and filler/LDPE specimens in the range of 0–800°C.

Table 1. Weight loss (%) of the following samples at different temperatures.

Samples	Dose (kGy)	Composition	T (°C)					
			150	300	450	600	750	800
LDPE	100	Pure	100	93.4	19.0	14.6	12.1	10.3
LDPE	—	Pure	100	92.5	10.8	9.2	6.5	6.1
EVA	100	Pure	100	100	70.0	2.5	1.6	0.4
EVA	—	Pure	99.7	98.0	58.7	1.5	0.3	0.0
MH	—	Pure	100	99.5	75.1	73.6	73.2	73.1
ATH	—	Pure	100	80.8	68.1	65.5	64.4	64.3
LDPE/MH	100	100/60	100	100	98.0	24.7	24.4	24.2
LDPE/ATH	100	100/60	100	96.5	55.0	17.0	17.0	17.0
LDPE/EVA/MH	100	45/5/70	100	96.1	52.8	32.4	32.6	32.0
LDPE/EVA/MH	100	40/10/70	100	98.5	58.6	35.1	34.3	34.0
LDPE/EVA/MH	100	30/20/70	100	98.9	61.4	36.3	35.2	35.1
LDPE/EVA/MH	100	20/30/70	100	99.1	62.2	37.9	36.8	36.4
LDPE/EVA/MH	100	10/40/70	100	100	63.1	38.6	38.6	38.6
LDPE/EVA/ATH	100	10/40/70	94.3	88.8	43.4	31.2	30.2	30.2
LDPE/EVA/ATH	100	20/30/70	99.3	93.1	49.8	34.2	33.2	32.6
LDPE/EVA/ATH	100	30/20/70	100	96.1	52.5	34.6	33.6	33.6
LDPE/EVA/ATH	100	40/10/70	100	96.8	55.1	35.8	35.1	34.8
LDPE/EVA/ATH	100	45/5/70	100	97.4	59.8	38.9	37.6	37.6

Figure 1 and table 1 show that non-irradiated LDPE deteriorates at 270°C; however, the irradiated LDPE (100 kGy) deteriorates at 295°C; this boosts polymer thermal resistance of LDPE and specimens against thermal breakdown owing to cross-linking bond formation in polymer matrix [1–7]. Figure 2 and table 1 show that the pristine polymers such as LDPE and EVA have high solubility in solvent, low strength and poor thermal stability. Therefore, to upgrade these characteristics, cross-linking, *via* the formation of networks or cross-link bonds, is a necessary solution for wide polymer application. Thermal decomposition of MH shows that the thermal breakdown of MH commences at 345°C, which represents the initial postponement of the weight loss and then it follows quickly when it is initiated. For ATH and MH specimens, TGA indications regularly display two stages: the first makes up 85% of the theoretical weight loss, owing to the bulk hydroxyls elimination, followed by the second gradual stage of surface hydroxyls [8–11]. Preliminary breakdown temperature of MH (345°C) is considerably higher than for ATH (225°C); amount of water released from MH in the temperature range 345–550°C is marginally lower than that for ATH as temperature changes from 225 to 600°C. All filler/LDPEs deteriorated in one stage somewhere in the range of 225–445°C. TGA results of (ATH or MH)/LDPE specimens indicate the weight losses of 20% in the range of temperature 10–20°C higher than that of the pristine LDPE. However, a minor weight loss of 10–15% for filling specimens is verified somewhere in the range of 225–400°C, which is smaller than that of the pristine LDPE. The minor weight loss at the reduced temperature is relevant to water loss due to the boundless or agglomerated areas of ATH and MH [12–15]. These

effective interactions influence the thermal strength of the filling material [16]. ATH deteriorates to Al_2O_3 and H_2O at 200°C [17–19]. The degree and extent of breakdown are determined by two pathways. Furthermore, in the direct breakdown of an oxide, a hydroxide/oxide intermediate $\text{AlO}(\text{OH})$ is produced that deteriorates at 500°C. The foundation of hydroxyl-oxide rises with a rise in ATH particle dimension [20–25]. Heterogeneous dispersion and aggregate development lead to hydroxyl-oxide formation [26]. Figures 1, 2 and table 1 show that the irradiated ATH and MH specimens commence their break-down at 225 and 415°C, respectively. Figures 1, 2 and table 1 show that the remainder for the irradiated and non-irradiated LDPE at 800°C is 0%; therefore, no protective layer lasts to shield at 800°C. The irradiated LDPE and EVA give high strength to weight loss at very high temperature owing to the development of cross-linking bonds in polymer matrices [27]. Figures 1, 2 and table 1 display the percentages of the remainder of MH and ATH specimens at 800°C, which are 73 and 64%, respectively. Figure 2 shows the thermal decomposition within 0–800°C of MH, ATH, LDPE/ATH and LDPE/MH compounds at 100 kGy. Figure 2 shows that MH is thermally more stable and that the percentage of the remaining material (MgO and Al_2O_3) within the temperature range of 600–800°C is also greater. Figure 2 reveals that the thermal stability of the irradiated LDPE/MH compound is more compared with the irradiated LDPE/ATH and that the residue proportion of protective ash for the MH compound is also bigger than that for the comparable irradiated ATH compound. These outcomes show that MH specimens generate a stronger and thermally more protective layer against oxygen diffusion than corresponding ATH specimens at high temperature.

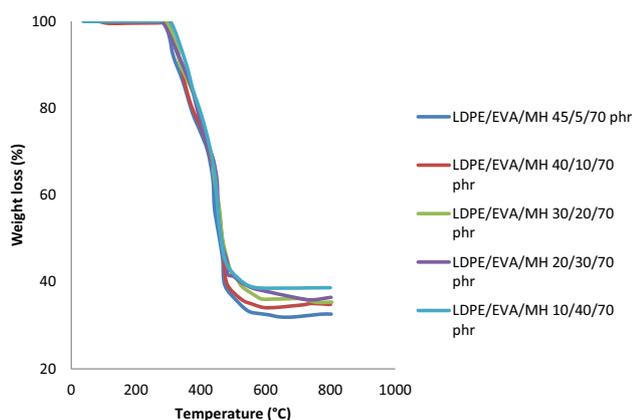


Figure 3. TGA outcomes of LDPE/MH composites.

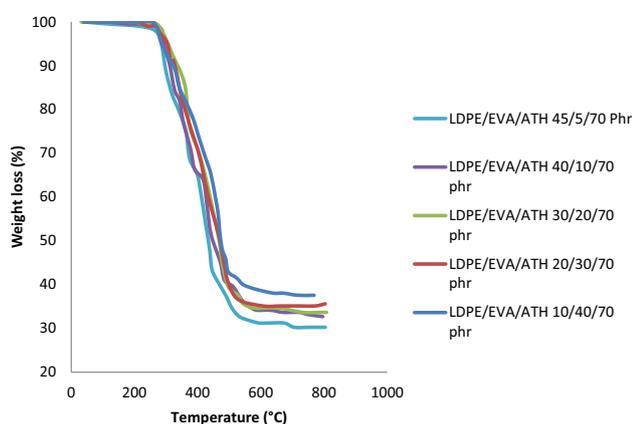


Figure 4. TGA outcomes of LDPE/ATH composites.

Figures 3 and 4 show the weight loss rates of LDPE/EVA/ATH and LDPE/EVA/MH when the temperature rises, respectively. The thermal breakdown of metal hydroxides starts at 190°C for ATH and 340°C for MH. The initial stage of the breakdown of EVA is related to the generation of acetic acid at temperature from 300 to 380°C, and the next stage is pertinent to the breakdown of remaining polyethylene and oxidation of remaining char [29]. However, LDPE deteriorates at temperature from 300 to 500°C in a particular mass-loss stage. Breakdown temperatures of water from MH specimens are considerably greater than that of the ATH specimen (from 360 to 550 vs. 190 to 380°C). These effects show that MH, as a fire retardant, is superior to ATH for LDPE and EVA matrices and MH resistance is thermally more stable, which is conveyed by the TGA tester, and it deteriorates at a temperature near that at which LDPE and EVA thermally deteriorate. Figures 3 and 4 imply the formation of extra ash residue by means of increasing EVA inclusions.

Table 2 presents the outcomes of cone calorimeter and LOI tests of LDPE. LOI experiment is carried out at the least dilution of oxygen in an O_2/N_2 blend to commence ignition, which therefore supports downward combustion of

a perpendicularly mounted test sample. LOI of neat LDPE is 18% (which is less than 21%); hence, if LDPE is subjected to fire, it burns without difficulty. Table 2 displays time-to-continued-combustion, peak heat release, time for the peak heat release rate (PHRR), total heat release (THR) of LDPE, the operating heat of ignition, average HRR at 60 s and mean HRR at 120 s, smoke extinction areas (SEA) and yields of CO, CO_2 . The outcomes are supported by the prior research works [1–3].

Table 3 presents outcomes from the inspected specimens in a systematic form. In table 3, LDPE/EVA compounds with MH or ATH included show a growth in LOI. LOI test is conducted to evaluate the ignition of polymeric materials, and supports the combustion test of polymeric specimens in a blend of oxygen and nitrogen, which can be used to examine the flame retardation of polymeric formulations [6]. MH and ATH, at high temperatures, produce water and deposition of MgO or Al_2O_3 on the outer surface of compounds, which protect the outer surface of compounds through cooling the outer surface and formation of barriers against heat transport into the composite materials [7–9]. The protective layers acted as barriers against heat transport into the deeper parts of the specimen. Formations of MgO and Al_2O_3 are able to delay the heat transport from flame into the materials, leading to a slower increase of temperature in the nanocomposite [28]. Due to environmental concerns, intumescent flame retardant is considered to be a promising HFFR additive due to the advantages of low toxicity and high flame-retarding efficiency. During combustion, the intumescent flame retardant produces a swollen multicellular char layer, which protects the underlying material from the action of the fire and acts as a physical barrier against heat transmission and oxygen diffusion, thus preventing pyrolysis of the materials to volatile combustible compound. Table 3 shows that inclusion of MH or ATH to LDPE/EVA compound leads to a growth in LOI. LOI depends on the components of the ingredients compared with 18 and 19% for pristine LDPE and pristine EVA, respectively. The smallest LOI reached is 31.18% for specimens containing MH, and LOI is raised with the further inclusion of EVA. An analogous growth in LOI is identified with further EVA inclusion for all ATH specimens. However, for the ATH specimens, the LOI is lower than that with corresponding MH compound. Table 3 shows that in LDPE/EVA/metal hydroxide specimens, the MH specimens delay the ignition more efficiently than the similar ATH specimens.

TGA and LOI results show that at the same inclusions, the MH specimens operate with better efficiency than the corresponding ATH specimens. Figure 5 displays that at each filler content, MH specimens show superior LOI and moreover, irradiation increases the LOI. This result shows that MH evolves water vapour at the next stage of ignition and MH affects the level of pyrolytic gas development, through developing char structures [7–9]. This higher fire strength is achieved through the formation of the enlarged carbonaceous composition on the fire front. In some conditions, the postponement of the polymeric ignition is related to the

Table 2. Ignition outcomes of pristine LDPE.

LOI (%)	18
Heat flux (kW m ⁻²)	35
TTI	43
Maximum RR (kW m ⁻²)	797
THR (MJ m ⁻¹)	2.76
Heat of combustion (MJ g ⁻¹)	38.3
Smoke extinction area (m ² kg ⁻¹)	801.4
CO evolution (kg kg ⁻¹)	0.004
CO ₂ evolution (kg kg ⁻¹)	1.40
Onset temperature (TGA), temperature and weight loss (DTG)	430°C, 633°C, 98%
Horizontal combustion tester (combustion duration and rate of combustion)	126 (s), 35.71 (mm min ⁻¹)

HRR: heat release rate; LOI: limiting oxygen index; SEA: smoke extinction areas; THR: total heat release; TTI: time to ignition; TGA: thermogravimetric analysis; DTG: differential thermogravimetric analysis.

Table 3. LOI of LDPE, EVA and composites.

Sample specimens	Formulations (LDPE/EVA) with MH or ATH	LOI (%)
LDPE/EVA	100/0	18.00
LDPE/EVA	0/100	19.00
LDPE/EVA with MH	(60/40) with 150	31.18
LDPE/EVA with MH	(40/60) with 150	33.78
LDPE/EVA with MH	(20/80) with 150	34.96
LDPE/EVA with ATH	(60/40) with 150	30.38
LDPE/EVA with ATH	(40/60) with 150	30.68
LDPE/EVA with ATH	(20/80) with 150	31.08

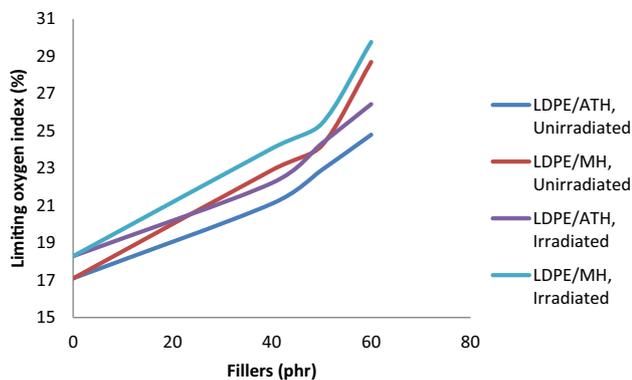
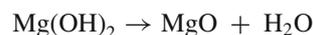


Figure 5. Irradiation effect and fillers on LOI of LDPE composites.

plasticity of char development at higher temperature [20]. Moreover, at high LOI values, the combustion duration is prolonged for all cross-linked specimens and it also resists dripping. MH offers operational flame-retardant characteristics *via* (a) evolving a considerable quantity of water at higher temperatures, which dilutes the fuel accessible and withstands the ignition in a flame, (b) taking up heat from the ignition area, which precludes the view of a normal combustion and

(c) formation of the metal oxide, which protects the sub-layer *via* combustion [25–29].



It is identified that inclusion of MH decreases the igniting through an endothermic reaction and water vapour production, which dilutes the fire gases and stabilizes the polymer sublayers [24]. The procedure of ATH performing the function of a non-halogenated flame retardant is highly eminent:



ATH is converted into Al₂O₃ and water *via* combustion and thermal decomposition. Al₂O₃ operates as a flame retardant, which creates a shielding layer to deter approaching oxygen to be provided for the flame, while the released water dilutes the gas phase and postpones the thermal decomposition of the polymer accordingly. The remainders become stable polymers melts as inert filler [25]. Oxygen diffusion protection is the outcome of generating a stretched out carbonaceous formation of the flame front [30].

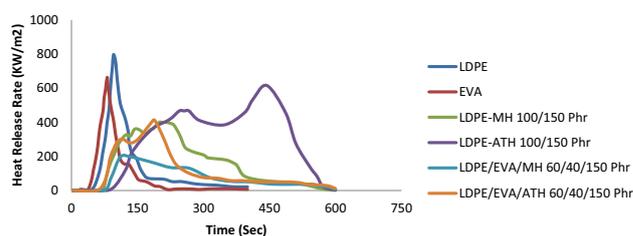
Table 4. Some cone calorimeter outcomes of LDPE, EVA and composites.

Sample specimens	THR (MJ m^{-2})	TTI (s)	PHRR (kW m^{-2})	TSR ($\text{m}^2 \text{m}^{-2}$)
LDPE/EVA	2.76	43	797	19.1
LDPE/EVA	2.52	33	664	25.5
LDPE/EVA with MH	1.58	71	200	11.7
LDPE/EVA with MH	1.58	72	193	13.6
LDPE/EVA with MH	1.85	74	234	14.1
LDPE/EVA with ATH	2.31	68	412	16.5
LDPE/EVA with ATH	2.40	72	460	18.0
LDPE/EVA with ATH	2.22	73	420	17.7

TTI: time to ignition; PHRR: peak heat release rate; TSR: total smoke release.

Table 4 displays the ignition of polymeric specimens relevant to the cone calorimeter tester. Ignition of the prepared formulations is examined with cone calorimeter machines. Table 4 verifies that in the sample specimens planned in table 3, MH inclusion hindered the combustion more effectively than ATH inclusion. Table 4 shows the value of reductions in the THR for the prepared metal hydroxide specimens in comparison with pristine LDPE, which depends on the category of used metal hydroxide and EVA content. Table 4 displays that the THR of specimens containing MH has a considerable drop of 60%. However, a small drop in THR is detected in the specimens containing ATH. Time to ignition (TTI) improved from 43 s (for pristine LDPE) and 33 s (for pristine EVA) to 68 and 74 s for the specimens in table 3. Table 4 shows that the TTI increases with EVA inclusion. A huge difference in TTI for the MH and ATH specimens in table 3 is not observed. The difference in combustion between MH and ATH specimens is related to the higher thermal strength of MH in comparison with ATH. A reduction in smoke growth is reached for pristine LDPE, EVA and EVA/LDPE/metal hydroxides (ATH or MH). Production of metal hydroxides and metal oxides during ignition leads to smoke suppression [25]. Therefore, metal hydroxides function as flame retardants and smoke suppressants. Table 4 exhibits a considerable drop in the total smoke release (TSR) for all MH specimens, similar to ATH specimens. Subsequently, there are severe peak heat release rates (PHRRs) for LDPE and EVA; however, with the inclusion of flame retardant the peaks dropped *via* various courses of combustion for all the MH and ATH specimens.

Figure 6 displays the HRR of LDPE, EVA and LDPE/EVA specimens containing ATH or MH. The highest HRR is attributed to pristine LDPE and EVA; however, the inclusion of metallic hydroxide to specimens reduced the HRR significantly. The HRRs for specimens with ATH contain are higher and the peak HRR value is two times larger than that for the corresponding specimens containing MH. As shown in figure 6, pure LDPE has a sharp and single HRR peak, and the PHRR is 797 kW m^{-2} at approximately 95.4 s. With the incorporation of flame retardants, the sharp HRR peak disappeared, and the PHRRs of composite containing ATH

**Figure 6.** Effect of combustion duration and fillers on HRR of LDPE composites.

and MH reduced significantly. Compared with pure LDPE, the PHRRs of the LDPE composites are reduced which is relevant to the synergistic flame-retardant systems, which reduce the initial peak effectiveness due to the formation of a char layer and consequent inhibition of volatile evaporation and heat transfer during burning [8]. In addition, the peak HRR of LDPE containing MH combined is obviously lower than that of corresponding composites containing ATH, and the incorporation of EVA can further decrease the HRR of the LDPE composites containing ATH. This is ascribed to the formation of a dense char residue with EVA. It is noted that the lower the HRR, the better the UL94 rating obtained in synergistic flame-retarded LDPE. The lowest PHRR values of LDPE composites containing 60 LDPE/40 EVA/150 MH can be ascribed to the combination of condensed and vapour phase mechanism, and EVA can promote the formation of char residue. Consequently, the specimens containing MH compared with the corresponding ATH compounds are safer and delay the ignition and combustion duration more in a fire situation.

Figures 7–9 summarize the smoke emission of the pristine LDPE, LDPE/ATH and LDPE/MH specimens. Figures 7–9 show that LDPE has the maximum smoke density quantities and the influence of ATH or MH has the proportional results to decrease the smoke density and the smoke emission of LDPE specimens. Besides, figure 7 presents that at the same flame retardant contain, the MH specimens have lower smoke densities than corresponding the ATH specimens which shows

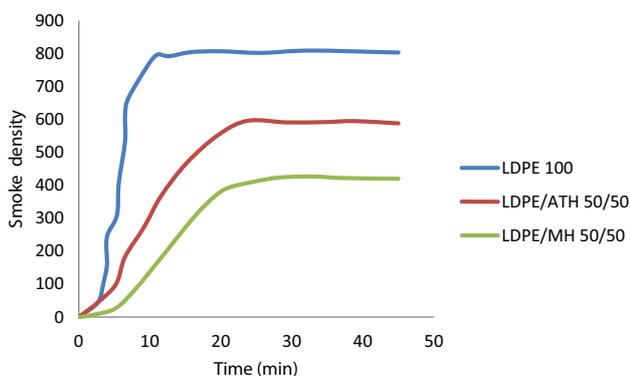


Figure 7. Densities of smoke emission of LDPE and composites.

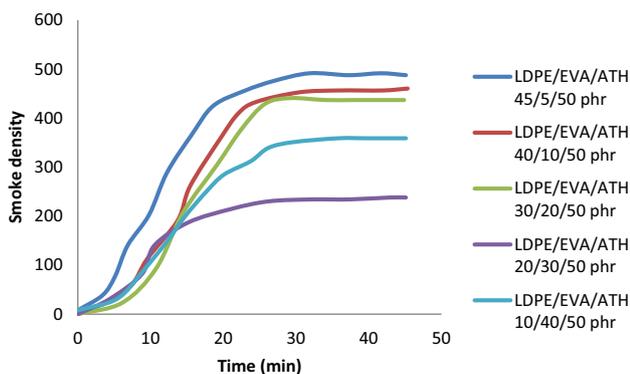


Figure 8. Densities of smoke emission of LDPE/ATH composites.

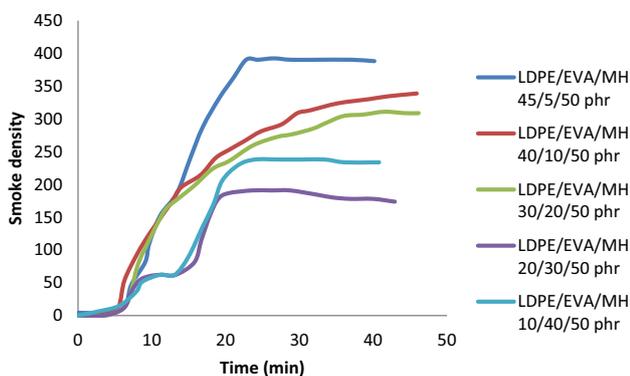


Figure 9. Densities of smoke emission of LDPE/MH composites.

MH is a safe and reliable flame-retardant additive throughout the polymer combustion.

Figures 8 and 9 display the effect of EVA inclusion to LDPE specimens and present the proportional impact of the smoke density reduction for the ATH and MH specimens. Smoke density for all MH specimens is less than those for corresponding ATH specimens. Smoke production through ignition keeps on a stepwise ring-growth mechanism and

involves three stages [23–26,30]. The polymer is initially and thermally deteriorated and generates a simple fuel. The simple fuel is then turned into reactive aromatic intermediates before it creates the smoke nuclei. At this point, the smoke nuclei regenerated to build up smoke particles [22–27,30]. The weights of the char-like remainder and the remainder of the LDPE/EVA/metallic-hydroxide-filled specimens reach the highest magnitude as EVA content reaches 30%. The outcomes identify that the char-like remainders retain the smoke nuclei and particles via combustion procedure, till the final point is completed.

4. Conclusion

TGA data revealed that for all the studied compounds, the samples containing MH are thermally more stable than the corresponding ATH compounds. The deterioration temperature for all ATH compounds is lesser than those for corresponding MH samples. The laboratory results showed that the inclusion of MH in LDPE dissuaded the combustion reaction, decreased smoke emissions and promoted thermal strength. Similarly, in comparison with non-irradiated samples, irradiated composites showed superior thermal strength and higher LOI values. The formation of cross-linking bonds during LDPE electron beam irradiation rendered it safe and secure at greater temperatures and exposure to fire. Irradiation as a practical technique is suggested for advancing the flame-retardant and the thermal strength characteristics of LDPE specimens. MH is suggested as a better halogen-free flame-lagging filler than ATH for producing wires that are accountable for function properly and offer safe resistance at elevated temperatures.

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