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Investigation of the mechanical and electrical properties of graphene nanoribbons -reinforced cementitious composites

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Abstract

This study researched the effect of graphene nanoribbons (0.05 wt%) on cement-based materials' mechanical and electrical properties. The results were compared with the ordinary Portland cement (OPC) paste and OPC paste with the same content of carbon nanotubes. The experiment results showed that after curing for 28 days, the compressive and splitting tensile strength of the sample with graphene nanoribbons were increased by 17.8% and 6.6% compared to OPC paste, and its reinforced effect for cement-based materials was superior to carbon nanotubes. Besides, due to the excellent electrical properties of graphene nanoribbons, the sample reinforced by graphene nanoribbons had a lower electrical resistivity (135.5 Ω·m) than OPC paste (418.5 Ω·m) and paste with carbon nanotubes (175.5 Ω·m). This proved the promising application of graphene nanoribbons on cement-based materials.

키 워 드 : 그래핀 나노리본, 기계적 강도, 전기적 특성, 시멘트 페이스트
Keywords : graphene nanoribbons, mechanical strength, electrical properties, cement paste

1. 서 론

It is well known that since cement-based materials (CBMs) were invented, they have been widely used and concerned due to their low price and superior performance of compressive strength. However, in the process of usage, CBMs are prone to cracking and show low splitting tensile strength, which restricts their performance. Therefore, there is a growing concern about the methods that can suppress the cracks produced by CBMs. With the nanotechnology development, nanomaterials have been added to CBMs not only to enhance the splitting tensile strength and inhibit crack generation and extension, but also to improve other properties of cement-based materials, such as electrical properties. This article will introduce a new nanomaterial that graphene nanoribbons (strips of graphene with a width less than 100 nm) have excellent mechanical and electrical properties and can facilitate the development of CBMs.

2. 재료 및 방법

Ordinary Portland cement (OPC) CEM I 42.5R was provided by Sungshin Company (South Korea). The multi-walled carbon nanotubes (CNTs) were purchased from Hengqiu Technology Company (China) as the nano reinforcing agent and the raw materials to synthesize graphene nanoribbons (GNRs). According to the previous research, the GNRs were synthesized via a chemical method, using a mixture of sulfuric acid, phosphoric acid, and potassium permanganate [1]. The morphology of CNTs and GNRs was shown in Fig. 1. Furthermore, The water to cement ratio was 0.3, and the content of the CNTs and GNRs was 0.05 wt%. Besides, the polycarboxylate superplasticizer (SP, ExCon SP20) was utilized to make the CNTs and GNRs uniformly dispersed in the cement matrix, and the added content was 1 wt%. The electrical resistivity, compressive strength, and splitting tensile strengths were measured after curing 1, 3, 7, and 28 days.

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3. 결과 및 토의

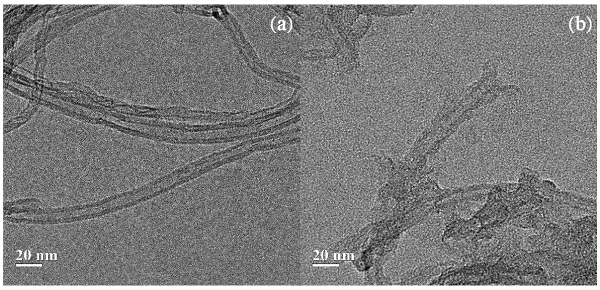

Figure 1. Morphology of CNTs (a) and GNRs (b).

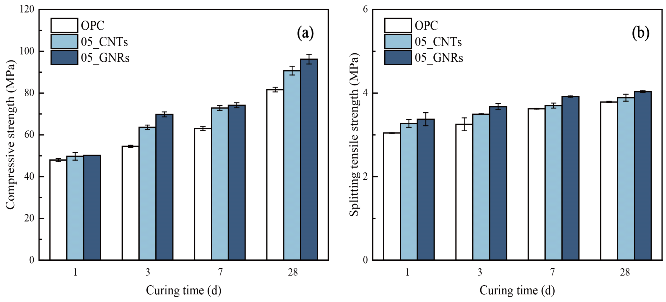

Figure 2. Compressive (a) and splitting tensile (b) strength of various samples.

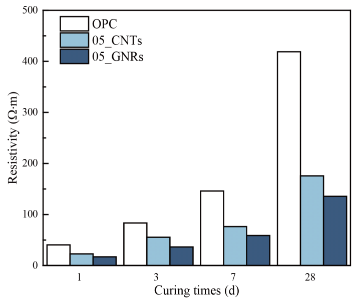

Figure 3. Resistivity of different samples.

Figure 1(a) showed that CNTs presented a tubular and multi-wall structure. After the chemical treatment, the GNRs exhibited a strip structure, and the multi-walled structure disappeared. This was due to the deconvolution of CNTs in the presence of strong acids. The structural differences also led to a change in the properties of CNTs and GNRs. Figure 2 exhibited the mechanical strength of various samples. After curing for 28 days, 05_GNRs paste showed the highest compressive and splitting tensile strength than OPC paste and 05_CNTs paste, which was attributed to the excellent filling effect and nucleation effect GNRs. Although CNTs also could increase the mechanical strength of the sample, the effect of CNTs was not as good as GNRs. As for the effect of GNRs on the electrical properties of CBMs, the results were presented in Fig. 3. As shown in Fig. 3, the resistivity of each sample increased with increasing the curing times owing to the water in the cement matrix reduced with a continuous hydration process. When CNTs and GNRs were added to the sample, the resistivity of the sample decreased compared to OPC paste due to CNTs and GNRs creating a conductive pass in the cement matrix. However, GNRs showed better electrical properties than CNTs and led the sample with 0.05 wt% GNRs had the lowest resistivity. Based on these results, we summarized that the GNRs could provide better the mechanical and electrical properties of CBMs than CNTs and suggested that the GNRs could be utilized as a new nano agent for CBMs.

감사의 글

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참 고 문 헌

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