

# Damping Properties of Piezoelectric Ceramics in Chlorinated Butyl Rubber

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**Abstract.** Piezoelectric ceramics (PZC) was a type of effective filler for improving the damping properties of CIIR composites. Experimental results revealed that incorporation of 20-40 phr of PZC into pure CIIR could change cure characteristics of these composites. At loading of 20-40 phr of PZC, the tensile strength was improved from 2.96 to 5.24 MPa, but the elongation at break showed an obvious decrease. Moreover, the damping loss fact of CIIR/PZC-20 was 1.42, increased about 30% in as compared with that of neat CIIR, 1.13. In addition, with addition of 30 phr of PZC into CIIR matrix, the electrical resistance was decreased for 4 orders of magnitude .

## 1. Introduction

With rapid development of modern industry, traffic tends to speed which inevitably produce a series of problems such as vibration, noise and fatigue fracture. This may accelerate the fatigue damage of vehicle structure, shorten the service life of vehicles, and endanger people's health. Therefore, the development of novel and efficient damping materials to reduce vibration and noise and improve the man-machine work environment is an urgent problem [1, 2].

Rubber damping material is one of the most important types of polymer damping materials. During the application and transportation process of rubber and its related products, their internal structure may be destroyed and ultimately lose the important application value of rubber itself due to the aging of a variety of internal and external factors [3-5].

Taking the idea of converting mechanical energy into electricity to dissipate, it is necessary to use piezoelectric ceramics as a functional additive for applications in rubber systems. Piezoelectric ceramics is a common damping material, enabling the conversion of electricity and heat between each other [6,7].

In this paper, we mainly introduced the method of mechanical blending CIIR with PZC, and the results of its performance, such as cure characteristics, tensile behavior, damping properties, and electrical resistance.

## 2. Properties of CIIR/PZT composites



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### 2.1 Cure characteristics of CIIR/PZT composites

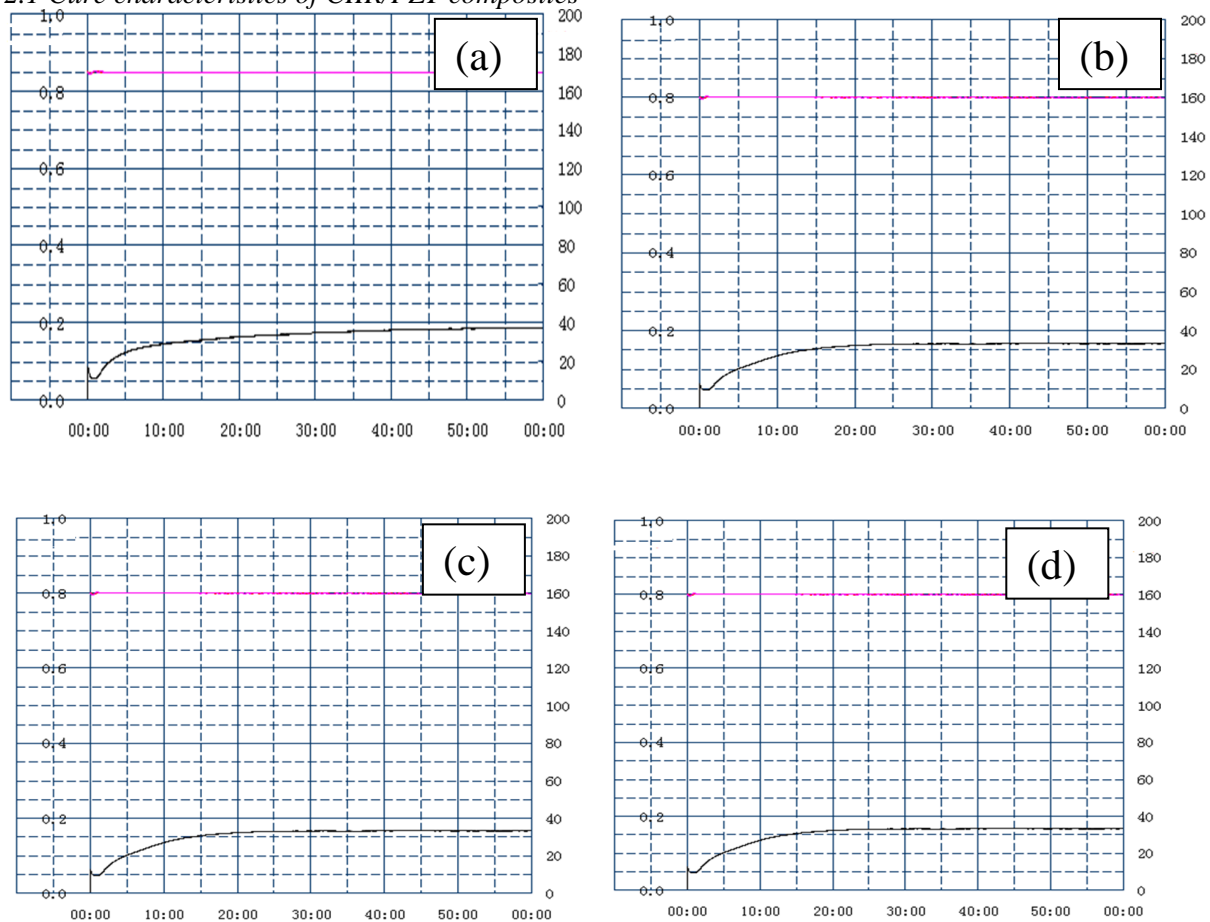


Figure 1. Cure curves of (a) CIIR, (b)CIIR/PZC-20, (c)CIIR/PZC-30,(d)CIIR/PZC-40

Table 1. Cure data of CIIR and CIIR/PZC composites

	CIIR	CIIR/PZC-20	CIIR/PZC-30	CIIR/PZC-40
T10	00:01:46	00:01:10	00:01:18	00:01:37
T90	00:15:32	00:30:44	00:15:25	00:29:44

Cure curves and the corresponding data of different CIIR composites were given in Figure 1 and Table 1. Almost similar trends were shown in these curves, and the cure time was about 30 min. T10 reflected the scorch time, and this means that a rubber can be safely processed in a given temperature before the curing process. T90 referred to the optimum cure time needed for the rubber to reach its maximum point, and at 90% of this level. Usually, the longer was the scorch time, the safer the rubber processing was. From above results, it can be revealed that the addition of PZC(20~40 phr) can decrease scorch time and make processing unsafe. In addition, the longer was the cure time, the more energy for the processing was used. It can be revealed that almost no energy was saved in the cure process resulted from the longer technical cure time.

### 2.2 Tensile properties of CIIR/PZC composites

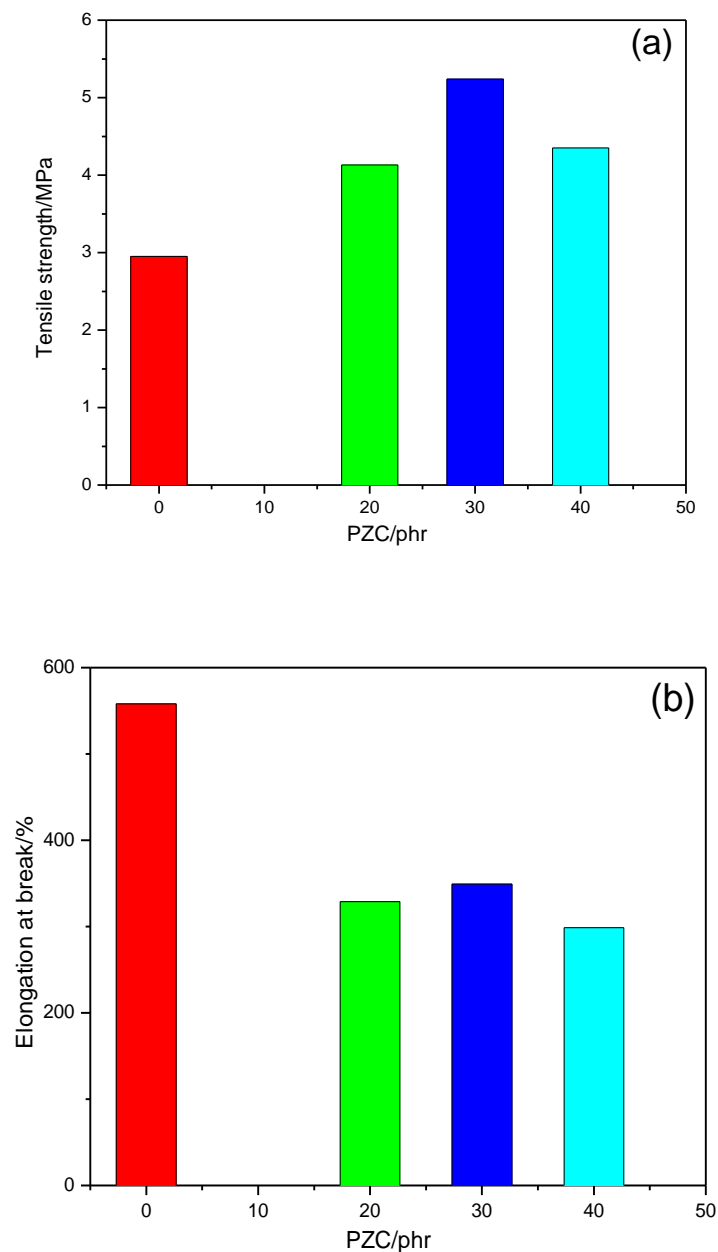
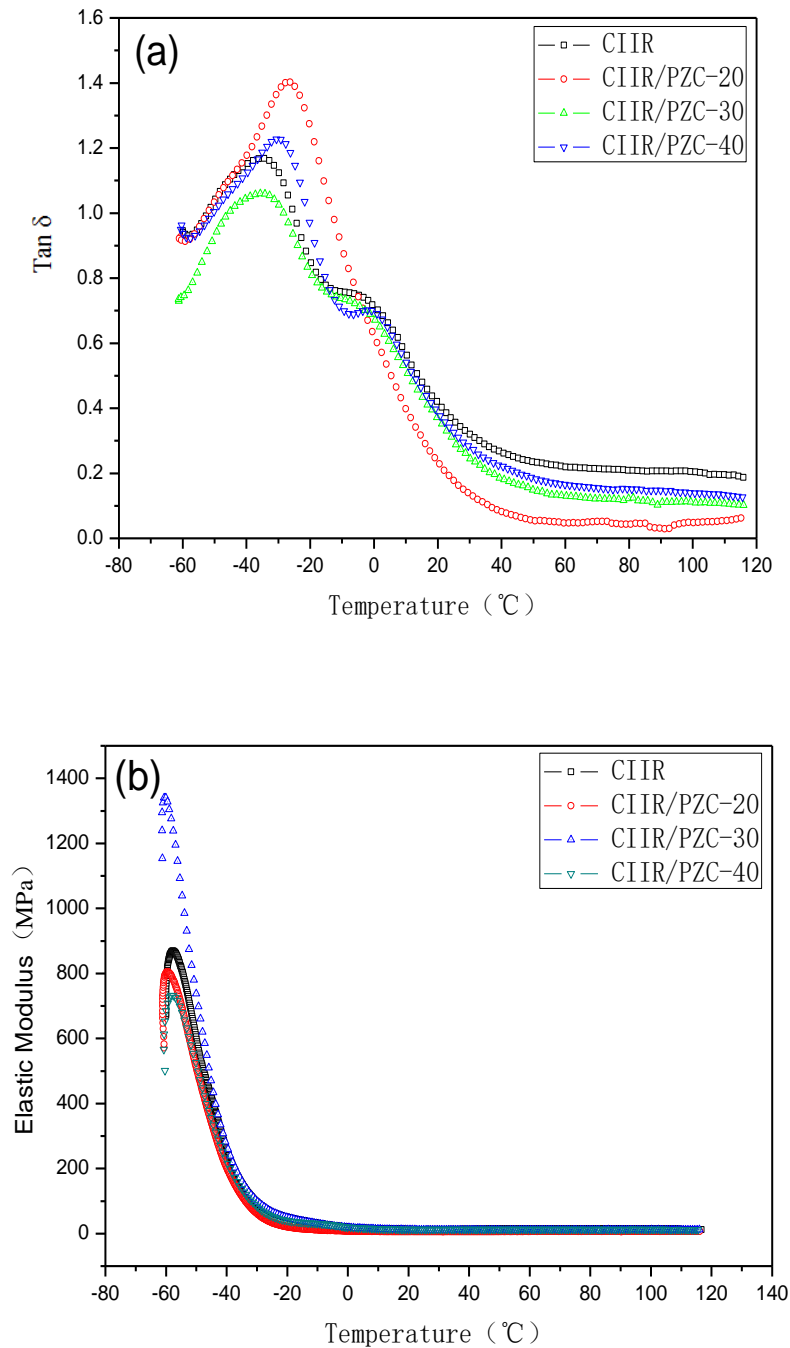


Figure 2. Tensile properties of different CIIR composites (a) tensile strength,(b) elongation at break.

Figure 2 presented the tensile properties of CIIR/PZC composites. It can be seen that different trends of tensile strength and elongation at break were shown for these CIIR composites. Their tensile strength was increased with the increasing amount of PZC (Figure 2(a)). At 30 phr, the CIIR/PZC composite showed the highest tensile strength, 5.24 MPa. This was 78% higher than that of pure CIIR, 2.95 MPa. However, the PZC aggregated when its content was increased. This led to the decrease of the tensile strength. In addition, the elongation at break showed almost different trend when this additive was incorporated. At loading of 20-40 phr of PZC (Figure 2(b)), the elongation at break of these composites was totally decreased. With addition of 30 phr of PZC, the elongation at break was 350%. This was 6%

higher than that of CIIR/PZC-20, 329%. The improvement of tensile strength was attributed to reinforcing effect of PZC due to its appropriate powder size.

### 2.3 Damping properties of CIIR/PZC composites



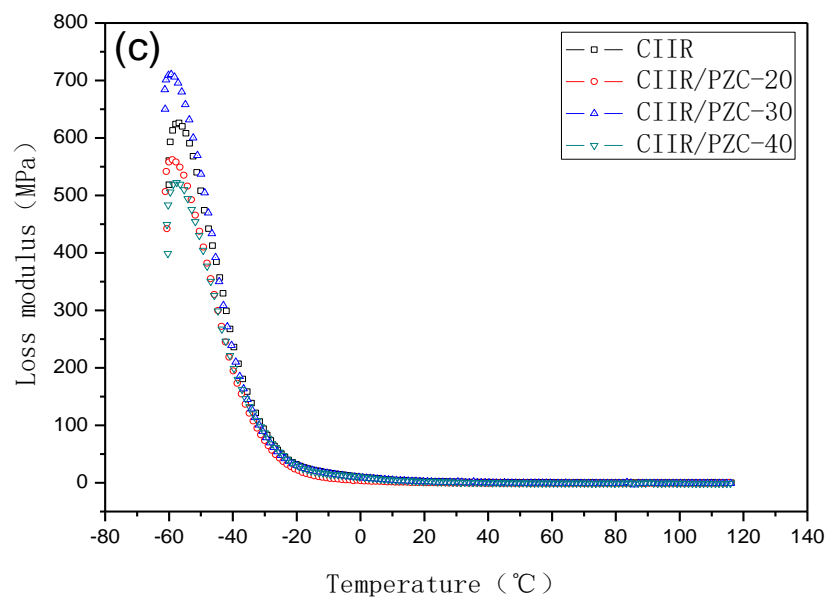


Figure 3. Damping properties of different CIIR composites  
(a) loss factors, (b) elastic modulus, (c) loss modulus.

As can be seen from Figure 3(a), CIIR/PZC-20 owned the highest damping factor ( $\tan \delta$ ), about 1.42, and this was about 30% higher than that of pure CIIR, 1.13. In addition, this damping factor was improved in the temperature ranges  $-40$  to  $0^\circ\text{C}$ . Although the glass transition temperature had a certain degree of movement to the room temperature region, the damping performance was decreased in the ambient temperature. From Figure 3(b), CIIR/PZC-30 exhibited the largest storage and loss modulus, which meant that this composite possessed the best tensile and damping properties. This was also in good accordance with their tensile properties (Figure 2(a)).

#### 2.4 Electrical performance of CIIR/PZC composites

Table 2. Electrical resistance of CIIR/PZC composites

Composition	Average resistance ( $\Omega \cdot \text{cm}$ )
CIIR	$1.4313 \times 10^{12}$
CIIR/PZC-20	$2.7620 \times 10^{16}$
CIIR/PZC-30	$1.8357 \times 10^{16}$
CIIR/PZC-40	$1.9200 \times 10^{16}$

As can be seen from Table 2, after adding different amount of PZC, the electrical resistance was increased by 4 orders of magnitude compared with that of pure CIIR. This illustrated that the addition of PZC powder can help to improve the insulation properties of rubber composites. However, as the amount of PZC increased again, the resistance of the rubber decreased which was due to the aggregation of this filler.

### 3. Conclusions

CIIR/PZC composites were prepared using PZC as damping agent. Different properties such as cure characteristics, tensile, damping, and electrical properties were investigated. The addition of PZC improved the tensile strength of CIIR composites. The composites with 30 phr of PZC exhibited the highest tensile strength, 5.24 MPa. Meanwhile, at loading of 30 phr of CIIR, the loss factor ( $\tan \delta$ ) was

1.42, and was increased about 30% compared with that of pure CIIR, 1.13. In addition, the electrical resistance of CIIR composites was improved after the addition of 20-40 phr of PZC.

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