Research on electrochemical corrosion of buffer layers inside the high-voltage cables based on electrochemical analyses

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ABSTRACT

Buffer layer is an important structure in the high-voltage cables, playing the role of buffering pressure, water-blocking and semi-conducting. However, such structure is the weakest layer among various layers in high-voltage cables. In this work, we studied the corrosion employing electrochemical analysis technologies including in-situ Tafel curves, electrochemical noise and open circuit potential. We found that the corrosion was inhibited under the test current of Tafel curves, which indicates the macromolecular anionic polymer in the buffer layer inhibited corrosion. This paper provides a meaningful reference for anti-corrosion of high-voltage cables.

KEYWORDS

Buffer Layer; High-Voltage Cable; Tafel Curve ; Electrochemical Analyses; Corrosion.

1.INTRODUCTION

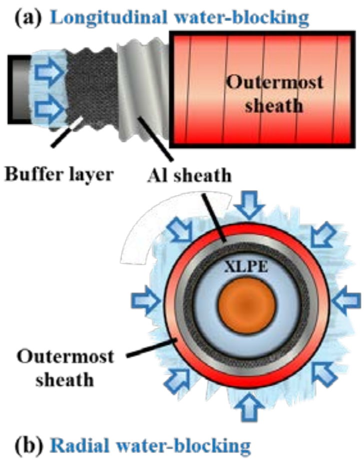

Fig. 1: Schematics of (a) longitudinal and (b) radial water blocking structures for high-voltage XLPE cables.

In high-voltage cables, water-blocking layers are often used to prevent moisture from entering the cable's interior and damaging its components, such as insulation and conductors[1]. There are two main types of water-blocking layers in cables: longitudinal water-blocking and radial water-blocking[2]. Longitudinal water-blocking is achieved by using sheath made by a material with a low permeability, including polymer and metal sheath[3]. This layer prevents water from penetrating the cable along its length, and is located outside the high-voltage cable[4]. On the other hand, radial water-blocking, typically buffer layer, is achieved by using a material with a high swelling capacity, such as swellable powder or tape, to fill the gaps between the cable core and the outer sheath. This layer helps prevent water from penetrating the cable radially, and is typically located outside the cable insulation layer[5].

Failure of the buffer layer is characterized by ablation tarnishing and the appearance of white spots, which cannot be repaired and can be costly to replace. Recent studies on buffer layer failures have focused on four main categories: composition analysis of white spots, factors affecting the buffer layer, buffer layer simulations, and detection methods for buffer layer failures.

However, there is limited research on the novel electrochemical corrosion at the interface between the buffer layer and the aluminum sheath. In this study, in-situ multiple Tafel curves, electrochemical noise, open circuit potential measurements were conducted to investigate the buffer layer.

2.EXPRIMENTAL

2.1 Materials

Semiconductive PET water-blocking tape (two types:contained and non-contained NaPA) and semi-conductive EVA, provided by Weihai Hanyu Chemical Textile Co., Ltd; Aluminum sheet, purity 98%, electrical grade; Deionized water, purchased from Aladdin Chemical Co., Ltd.

2.2 Experimental device

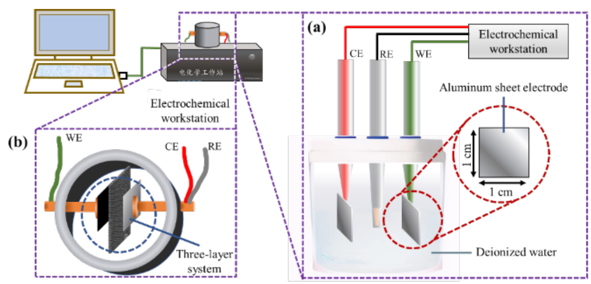

Fig. 2 Diagrams of connection modes. (a). Al sheet sample in an electrolytic cell (Sample 5). (b), Three-layer system samples in a ceramic cup (Sample 1-4).

The device for electrochemical tests is shown in Fig. 2. A three-layer system is sandwiched between two electrodes in a ceramic cup[6]. A three-layer system contains aluminum sheet, buffer layer sheet, and semi-conductive EVA sheet (to prevent corrosion from occurring between the electrode and the buffer layer sheet). In a controled area between the buffer layer sheet and the aluminum sheet, 0.5 mL of deionized water is dripped with a needle tube. One end of the electrode is connected to a working electrode (WE), while the other electrode is connected to a reference electrode (RE) and an auxiliary electrode (CE).

Table. 1 Information of samples