Development of XLPE Nano-Composite Used for HVDC ±250kV Cable System Applicable to LCC and VSC

JH **NAM**, SI **JEON**, IH **LEE**, WK **PARK;** LS Cable & System, Korea,
jin-ho.nam@lscns.com, sijeon@lscns.com, ganaihl@lscns.com, wkpark@lscns.com,
S **HWANGBO**, HONAM University, Korea, hbs@honam.ac.kr
JT **KIM,** DAEJIN University, Korea, jtkim@daejin.ac.kr
JH **LEE,** HOSEO University, Korea, leejh@hoseo.edu
JY **Koo,** HANYANG University, Korea, koojy@hanyang.ac.kr

ABSTRACT

XLPE Nano-composite has been developed after several years' research works for HVDC ±250kV cable and outdoor termination applicable to LCC & VSC type. Related fundamental laboratory tests on the specimen show very low homo-charge accumulation and high volume resistivity with less dependency on temperature. A prototype ±250kV XLPE cable system for LCC has been designed and manufactured at Donghae plant of LS Cable & System. Afterwards, relevant tests have been fulfilled according to CIGRE TB 496 LCC and VSC protocol at KEPCO Gochang Test yard and also separately approved by KOLAS (Korea Laboratory Accreditation Scheme).

KEYWORDS

Nano-composite, XLPE, HVDC, Cable System, Cigre TB 496, LCC & VSC, KOLAS

INTRODUCTION

Since 1960s, XLPE has been widely used for electric AC power cable insulation ascribed to its relatively preferred technical advantages, such as high breakdown strength, excellent thermal and mechanical properties. However, its use for DC transmission cable has not been remarkably accepted considering the decrease in breakdown strength during the operation and the accumulation of space charge. In particular, it has been known that the latter could give rise to the distortion of the electric field distribution inside the cable insulation system. Thus, since the beginning of 1990s, it has been suggested to introduce nano-materials into XLPE for being pertinently suppressed [1-6].

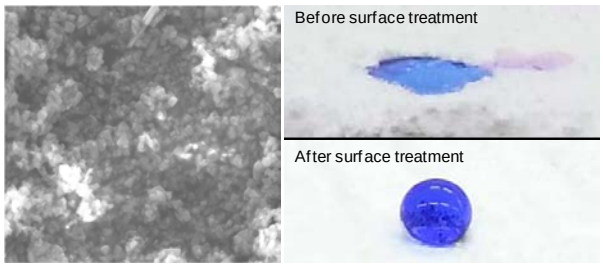
Regarding the converter, there are two types: LCC (Line Commutated Converter) controls the current using thyristor whereas VSC (Voltage Source Converter) controls the voltage by power IGBT. The latter is leading the XLPE DC cable market so far ascribed to the rapid progress of the related technology along with the high demand of voltage upgrade. Thus, the type of HVDC cable depends on the converter application and accordingly different methods are required respectively in order to suppress the space charge accumulation.

In Korea, a research consortium has been launched to develop several nano-materials for their compounding with XLPE. Thus, material and cable specialists in academia and industry have joined together: surface treatment of nano-materials and the compounding with XLPE have been dealt with. Eventually, a XLPE nano-composite employable to HVDC power cable has been obtained showing relevant engineering performance. This paper describes a development of HVDC ±250kV Cable System applicable to LCC and VSC.

DEVELOPMENT OF HVDC XLPE MATERIAL

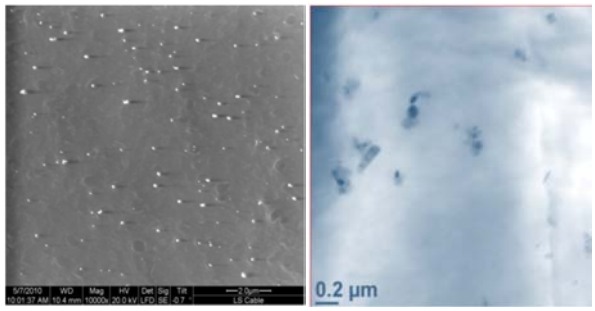
XLPE nano-composite

Many research works have been carried out to obtain relevant electrical properties of nano-materials employable to HVDC cable insulation. Mostly, the surface of the inorganic nano-material shows normally polarity, which requires a surface modification process when they are dispersed and mixed with host material such as nonpolar polyethylene in our case.



(a) SEM **(b) Presence of Water droplet**

Fig. 1: SEM & Optic image of inorganic nano-materials



(a) SEM **(b) TEM**

Fig. 2: SEM & TEM for XLPE nano-composite

In Fig. 1 (a), SEM shows the inorganic nano-material under our consideration. Fig. 1 (b) shows the optical observation of the presence of water droplet on the surface of inorganic nano-material before and after its surface treatment: water droplet is completely absorbed before and maintains its own shape after. The surface treated inorganic nano-material has been selected for compounding with polyethylene, for which many technical issues have been improved with respect to processing machines, conditions, and related analyses. In particular,