Aqueous Exfoliation of Transition Metal Dichalcogenide and Their Antibacterial Activity

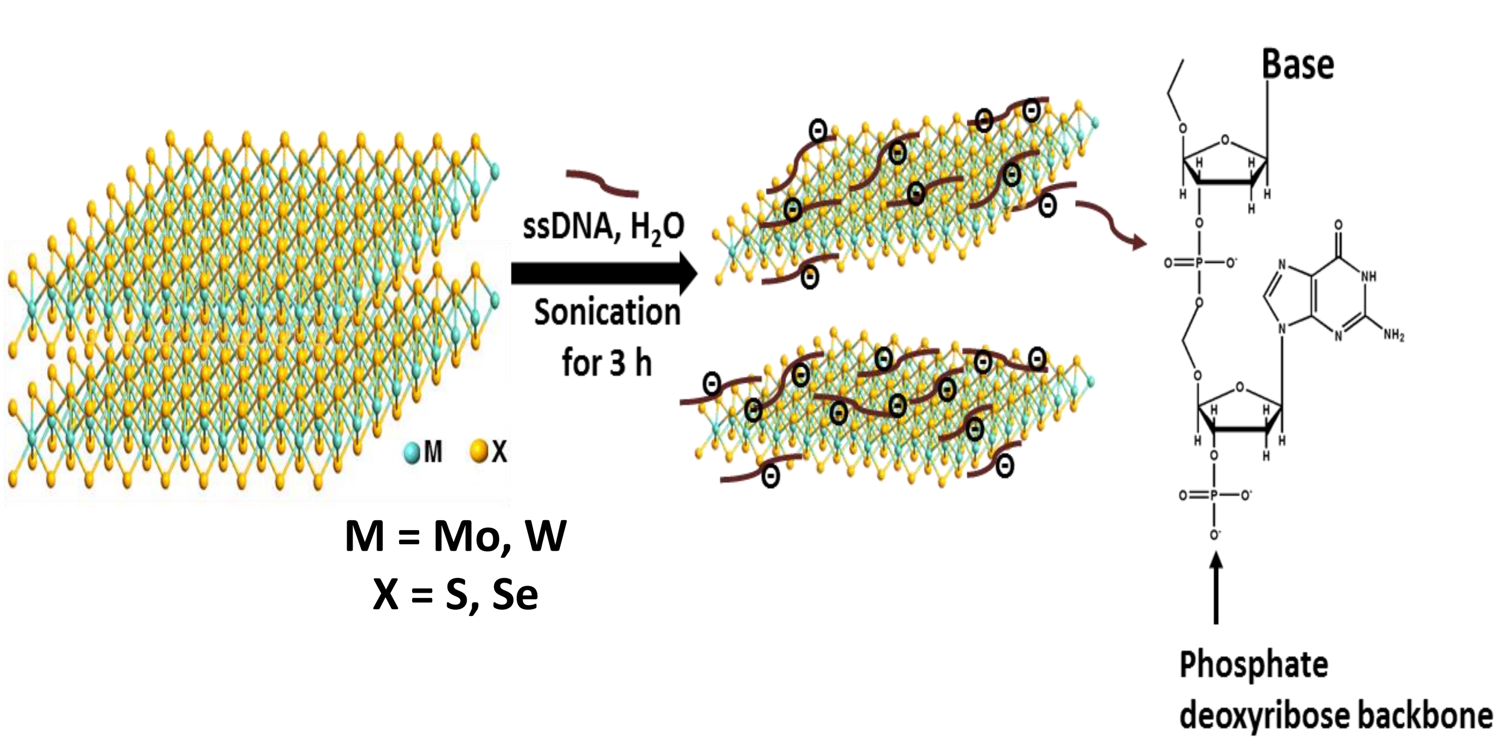
Gyeong Sook Bang, Gi Woong Shim and Sung-Yool Choi*

Graphene Research Center and Department of Electrical Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea

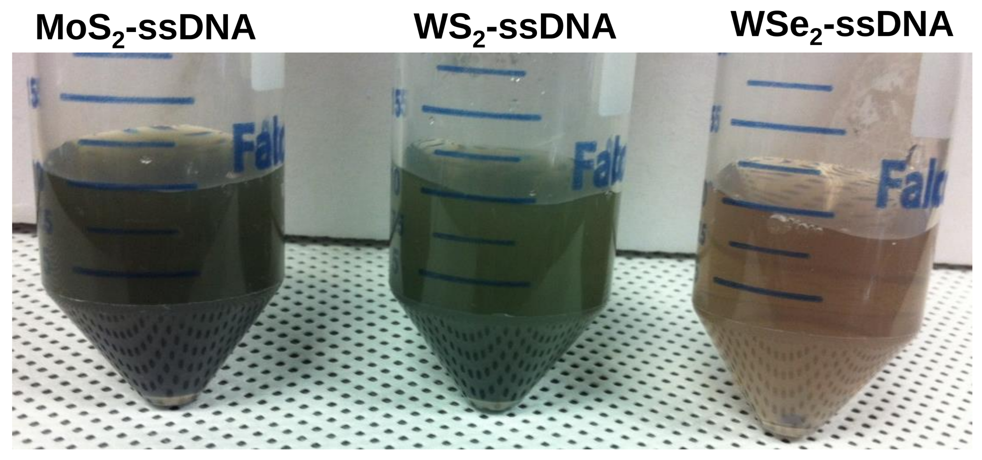
INTRODUCTION

MX_2 is an insoluble compound, which has hindered the preparation of well-dispersed 2D MX_2 nanosheets under aqueous conditions. The poor solubility is limited to large-scale production and biological applications of MX_2 nanosheets. We report a method for high-yield exfoliation of MX_2 using single-stranded (ss)DNA by sonication under aqueous conditions. ssDNA provided a high degree of stabilization and prevented reaggregation, and enhanced the exfoliation efficiency of MX_2 nanosheets due to adsorption on the WX_2 surface and the electrostatic repulsion of sugars in the ssDNA backbone. The exfoliation yield was higher with ssDNA (80%–90%) than without (2%–4%). Given that two-dimensional nanomaterials have potential health and environmental applications, we investigated antibacterial activity of exfoliated WX_2-ssDNA nanosheets relative to graphene oxide (GO), and found that WSe_2-ssDNA nanosheets had higher antibacterial activity against *Escherichia coli* K-12 MG1655 cells than GO. Our method enables large-scale exfoliation in an aqueous environment in a single step with a short reaction time and under ambient conditions, and can be used to produce surface-active or catalytic materials that have broad applications in biomedicine and other areas.

ssDNA-Assisted Exfoliation of MX_2

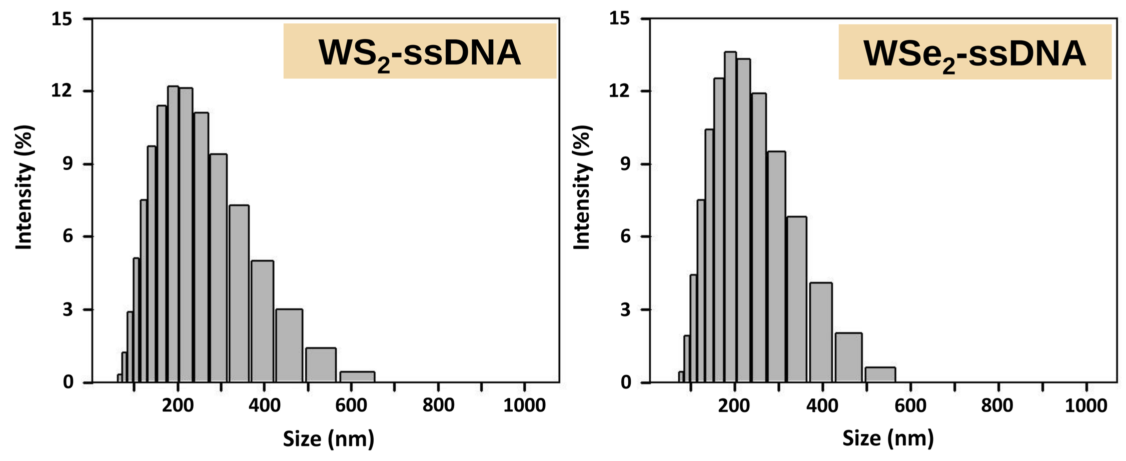


Aqueous dispersion of MX_2-ssDNA nanosheets



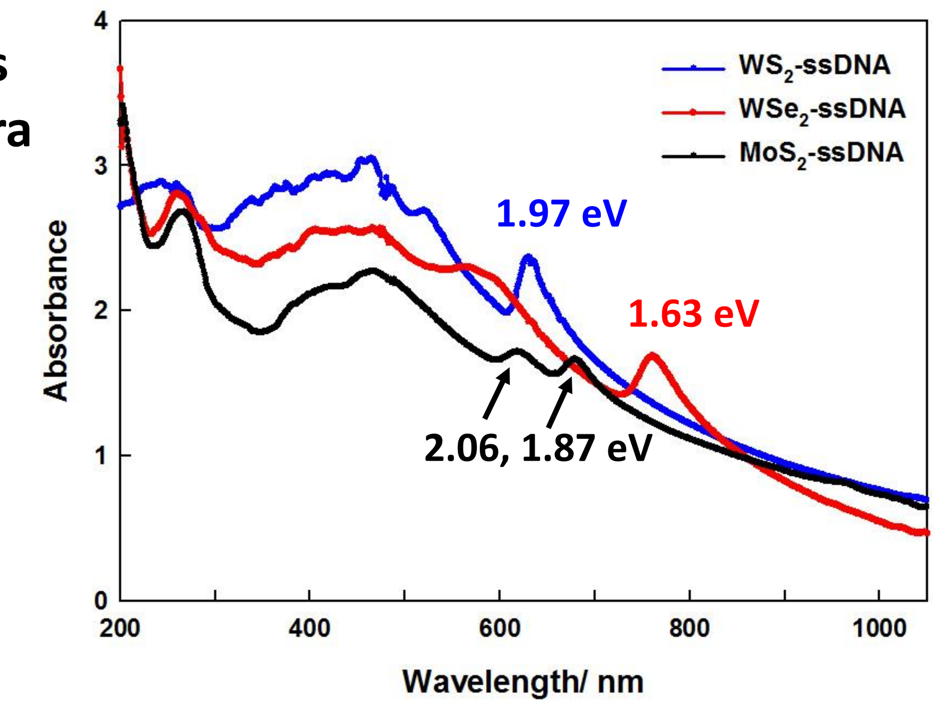
Zeta potential : -35 mV for MoS_2, -37 mV for WS_2, -36 mV for WSe_2

Lateral size : 60 nm ~ 1 μm, thickness: < 5nm

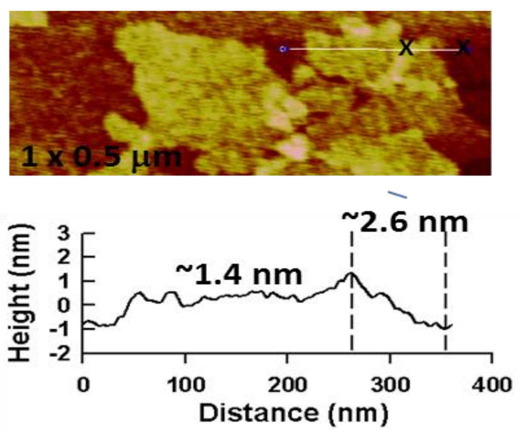


Characterization of MX_2-ssDNA dispersion

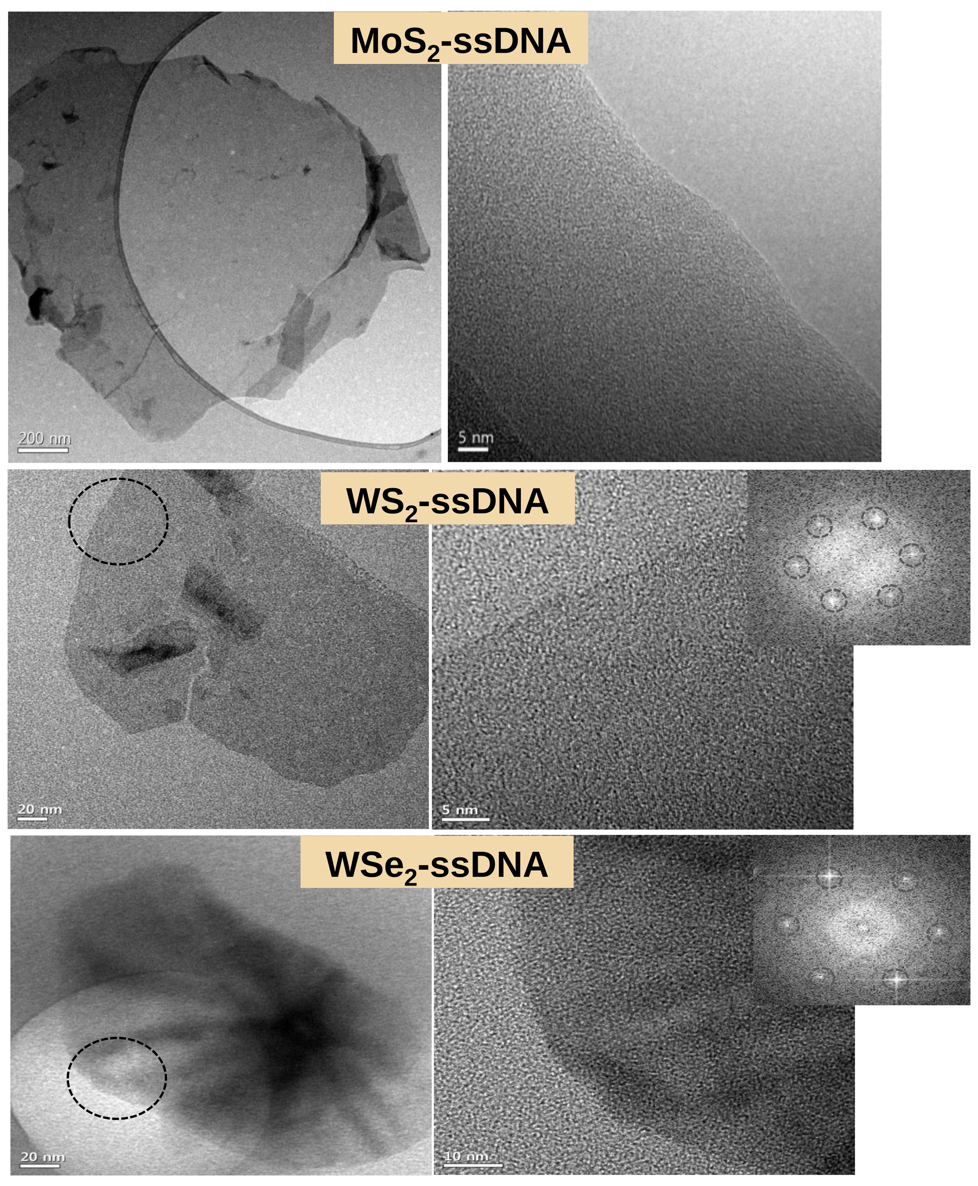
UV-vis Spectra



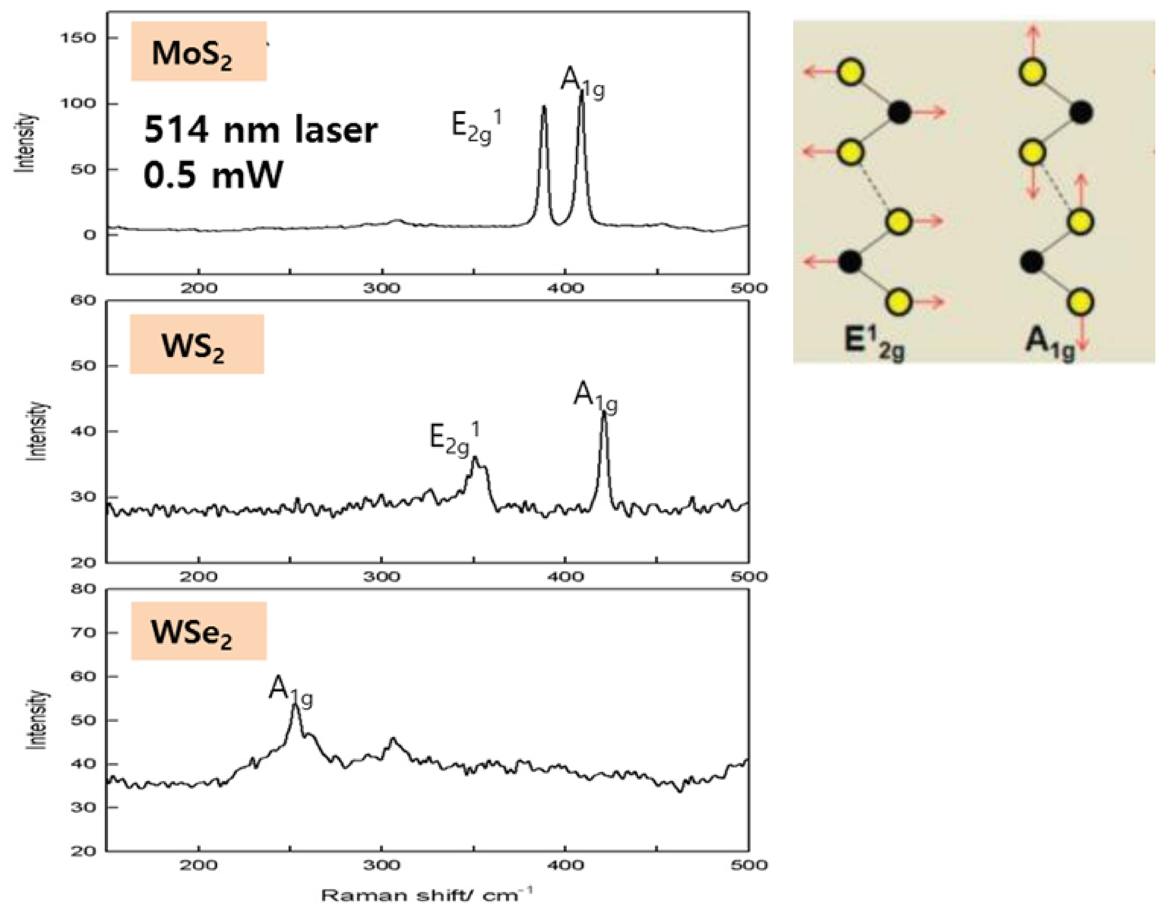
AFM Image



TEM Images of MX_2-ssDNA nanosheets

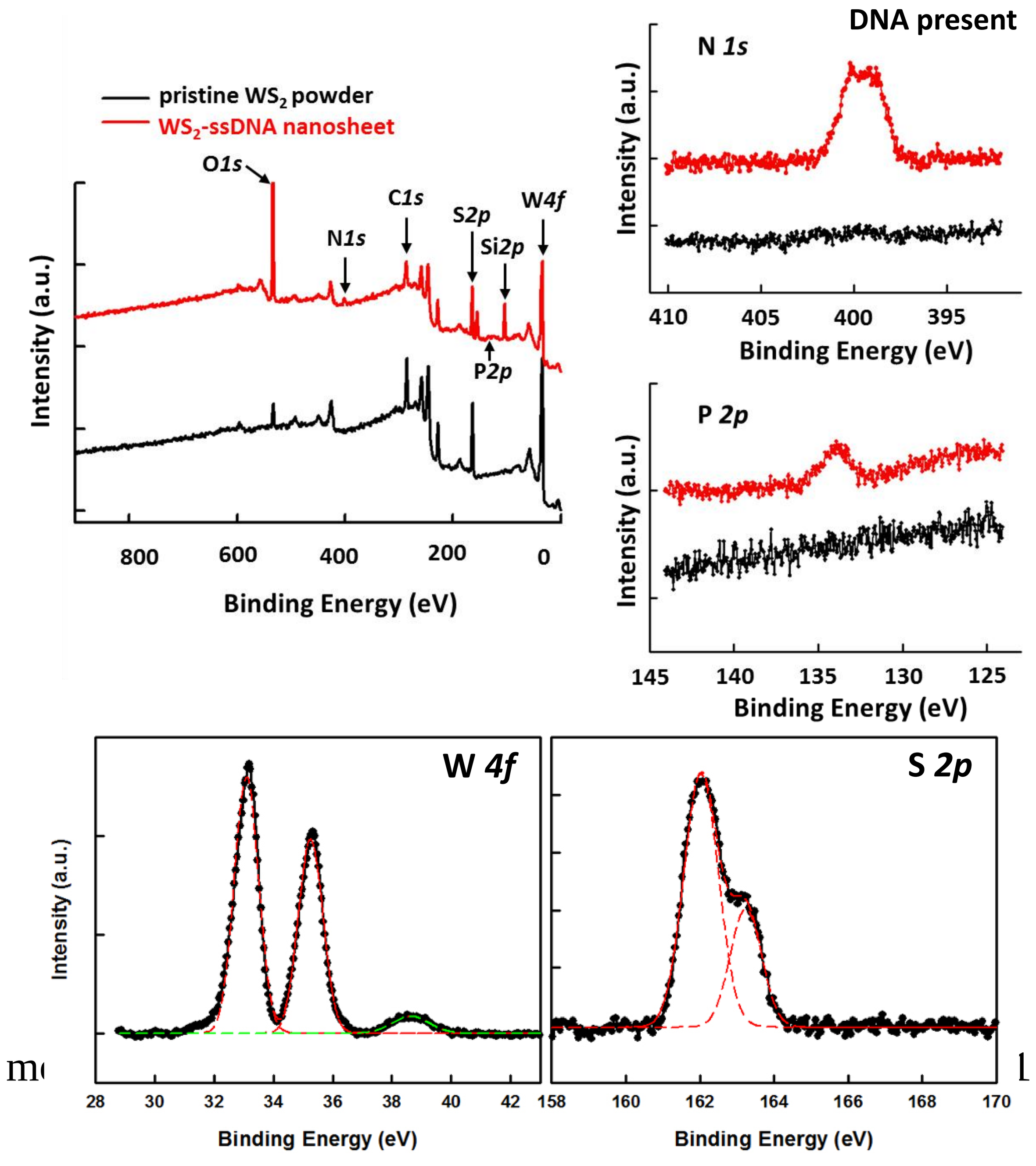


Raman Spectra of MX_2-ssDNA nanosheets on SiO_2/Si substrate

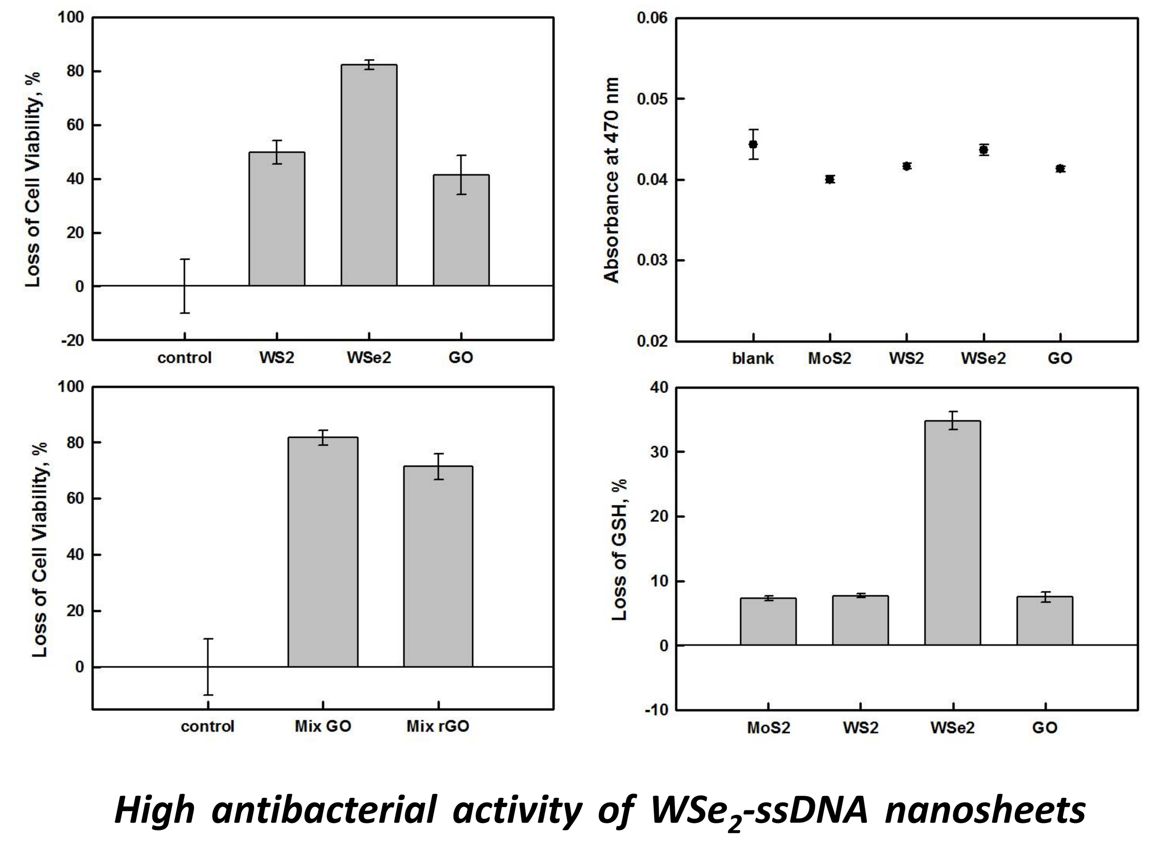


Two typical peaks-E_{2g}, originating from the in-plane mode vibration of M-X, and A_{1g}, from the out-of-plane vibrations of X atoms were observed.

XPS spectra of WS_2-ssDNA



Antibacterial activity



High antibacterial activity of WSe_2-ssDNA nanosheets against E. coli

CONCLUSION

1. *This exfoliation method can be used to prepare MX_2 nanosheets with high exfoliation efficiency (80-90%) and good aqueous dispersibility.*
2. *The thickness of MX_2-ssDNA nanosheets by AFM was 1.4 – 2.6 nm and the size was observed in the range of 60 nm - 1 um.*
3. *For health and environmental applications, we investigated antibacterial activity of exfoliated MX_2-ssDNA nanosheets and WSe_2-ssDNA nanosheets had higher antibacterial activity against E. coli K-12 MG1655 cells than MS_2-ssDNA and GO.*

Graphene Research Center & Department of Electrical Engineering, KAIST
291 Daehak-ro, Yuseong-gu, Daejeon, 305-701, Republic of Korea
E-mail: * Corresponding author: sungyool.choi@kaist.ac.kr, 1st author: smilegs@kaist.ac.kr
Phone: +82-42-350-7527,7627,8523