

## Ballistic impact characteristics of soft bulletproof plate of shear thickening fluid (STF)-Hanji

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### 1. Abstract

Over a millennium, Hanji, was used in many fields due to the convenience of supply and eco-friendliness. Also, Hanji consists of long fiber cellulose resulting in excellent tensile strength, toughness, and impact resistance. Shear thickening fluid-which a viscosity of a fluid dramatically increases as strain rate increases-was combined with Hanji to produce a light-weight and soft bullet-proof plate.

To develop a light-weight and thin bullet proof materials, research on shear thickening fluid plate was initiated. Along with the light and thin properties, the fluid dissipates momentum of the bullet efficiently preventing penetration depth. However, due to its outrageous price, it is still in progress to commercial use.

Compared to commercial bullet-proof plates, the plate behaves as a soft plate in routine activities and transforms to a rigid plate when a bullet impacts. The mechanical properties of Hanji, and Corn starch suspension was determined by experiments. Next, the weight ratio of Hanji and cornstarch suspension was optimized. Lastly, the thickness of the plate was found by simulation and tested down range. This study can have a huge effect on appropriate technology in combat zones with less resources.

[4] Shim, G.-I.; Kim, S.-H.; Ahn, D.-L.; Park, J.-K.; Jin, D.-H.; Chung, D.-T.; Choi, S.-Y. Experimental and numerical evaluation of transparent bulletproof material for enhanced impact-energy absorption using strengthened-glass/polymer composite. *Composites Part B: Engineering* **2016**, 97, 150.

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### References

- [1] Haro, E. E.; Odeshi, A. G.; Szpunar, J. A. The energy absorption behavior of hybrid composite laminates containing nano-fillers under ballistic impact. *Int. J. Impact Eng.* **2016**, 96, 11.
- [2] Xie, W.; Tadepalli, S.; Park, S. H.; Kazemi-Moridani, A.; Jiang, Q.; Singamaneni, S.; Lee, J.-H. Extreme Mechanical Behavior of Nacre-Mimetic Graphene-Oxide and Silk Nanocomposites. *Nano letters* **2018**, 18 (2), 987.
- [3] Wan, F.; Jiang, Z.; Tan, Q.; Cao, Y. Response of steel-tube-confined concrete targets to projectile impact. *Int. J. Impact Eng.* **2016**, 94, 50.