

Optimization of Spinel Absorber Coatings for CSP Particle Receivers

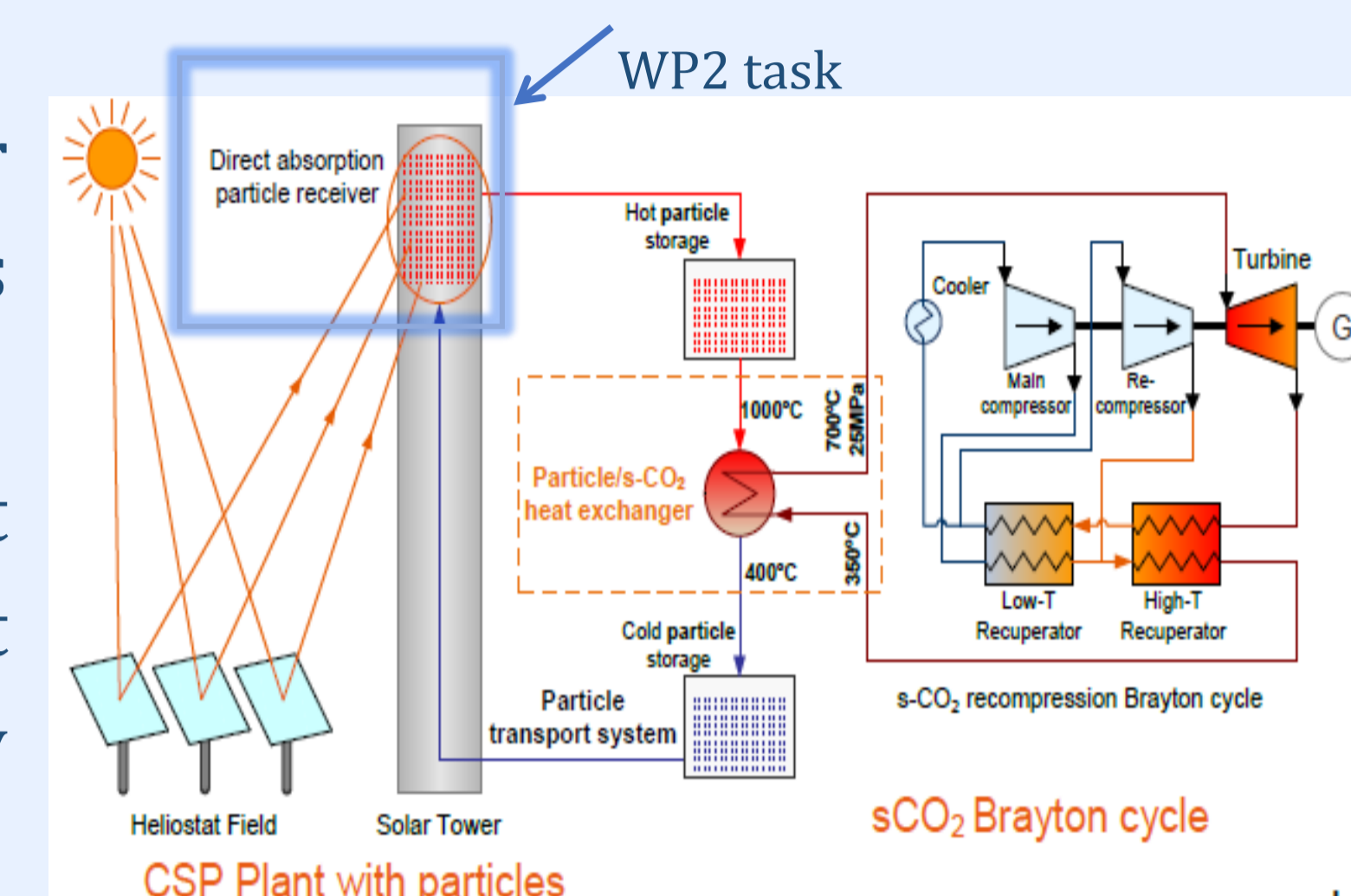
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Motivation and Objectives

- High operating temperature leads to higher power conversion efficiency and lower cost. Therefore, there is an increasing interest in improving the current commercial plants of concentrating solar power systems (CSP).
- Nowadays, solid particles are potential candidates to be used as receiver in CSP plants to increase their operating temperature (in order of 1000 °C) and efficiency. Additionally, these particles can be used as thermal storage medium reducing in this way the complexity and costs of the system.
- The novel concept of using a solar receiver constituted by solid particles that are responsible of the direct solar radiation absorption is pursued within the HORIZON 2020 COMPASsCO2 project. Along this project the CSP particle systems are integrated into a highly efficient CO2 Brayton power cycles for electricity production.

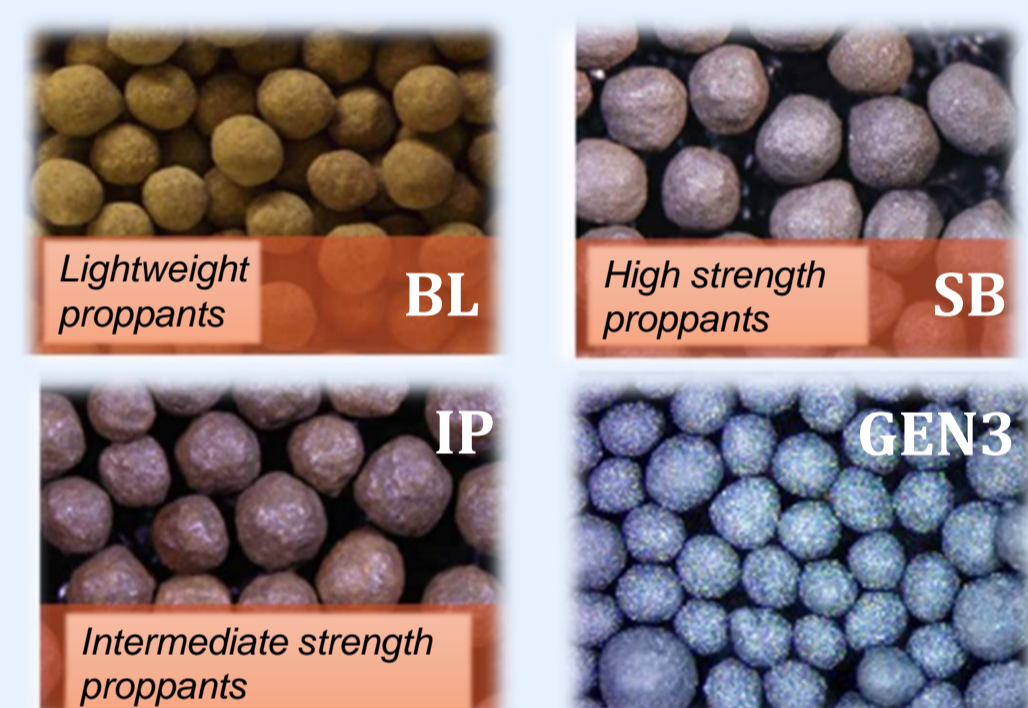
Hence, these solid materials require withstanding high temperature oxidation and erosion.



The main tasks within the WP2 focuses on the design, development and test high performance particles for CSP receivers.

Experimental Methodology

Four porous “state-of-the-art” particles (BauxLite/BL (two particle sizes), Sintered Bauxite/SB and Interprop/IP) and a new granulated particle candidate (GEN3) developed by Saint-Gobain have been coated with new designed coatings.



The influence of depositing consecutive spinel-layers on particles and their curing temperature on the optical properties have been analysed.



Perkin Elmer Lambda 950 UV-VIS-NIR spectrophotometer



Perkin Elmer Frontier FTIR spectrophotometer

The resistance to abrasion and thermal durability of spinel coating on particles supplied have been studied.



TABER oscillating tester mod. 6160



Selecta electric muffle furnace N-13L

Results

Influence of the curing temperature and the consecutive deposition of spinel-layers on the solar absorptance (α_s)

Table 1. Description of the two methods used for sintering the spinel coatings. Experiments carried out using the pristine spinel composition (Sol B)

Methods of heat treatment	
Method 1	Method 2
Each deposited layer of spinel was sintered at 600 °C, 1 h.	Each deposited layer of spinel was sintered at 1000 °C, 2 h.
After the fourth layer, the particles were heated at 1000 °C, 2 h.	

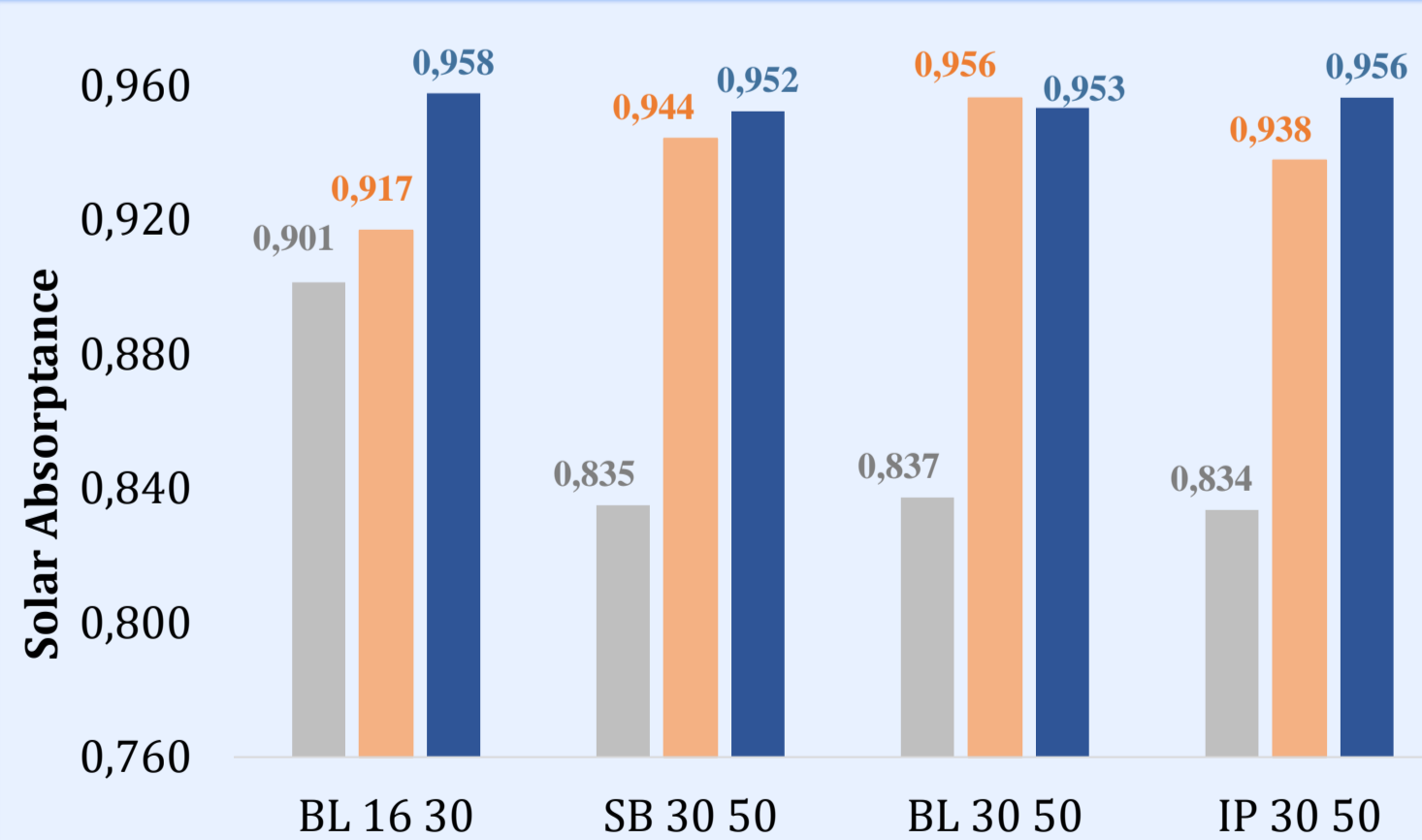


Fig. 1 Effect of the spinel sintering on the α_s for the porous state-of-the-art particles tested.

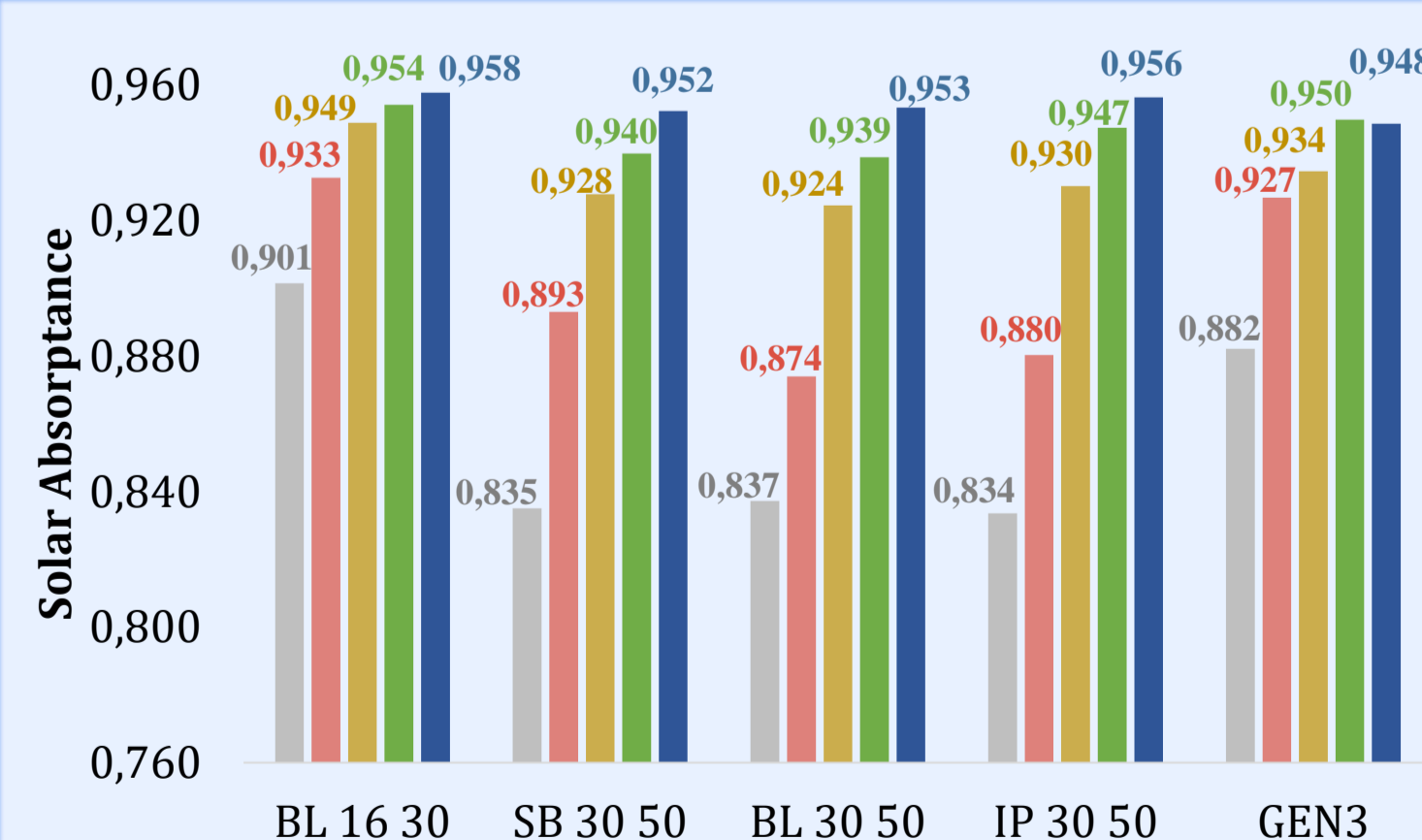


Fig. 2 Effect of depositing consecutive spinel-layers on the particles tested. Method 2 of heat treatment.

Influence of depositing a new porous spinel solution (SiO₂/spinel coating) on the latest solid particle candidate GEN3

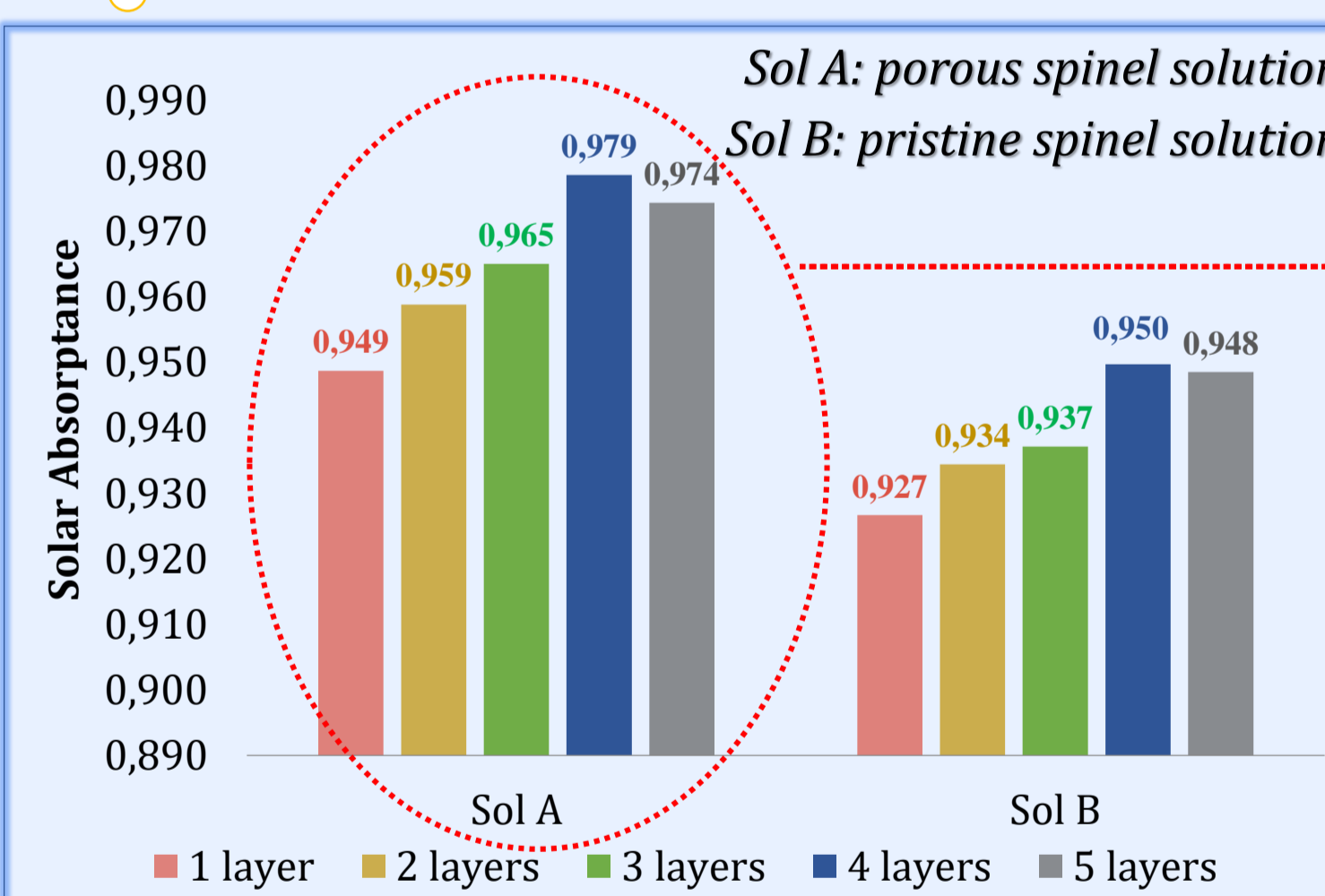


Fig. 3 Effect of both spinel composition and number of layers applied on GEN3. Method 2 of heat treatment.

GEN3: higher hardness and heat capacity than the porous “state-of-the-art” particles

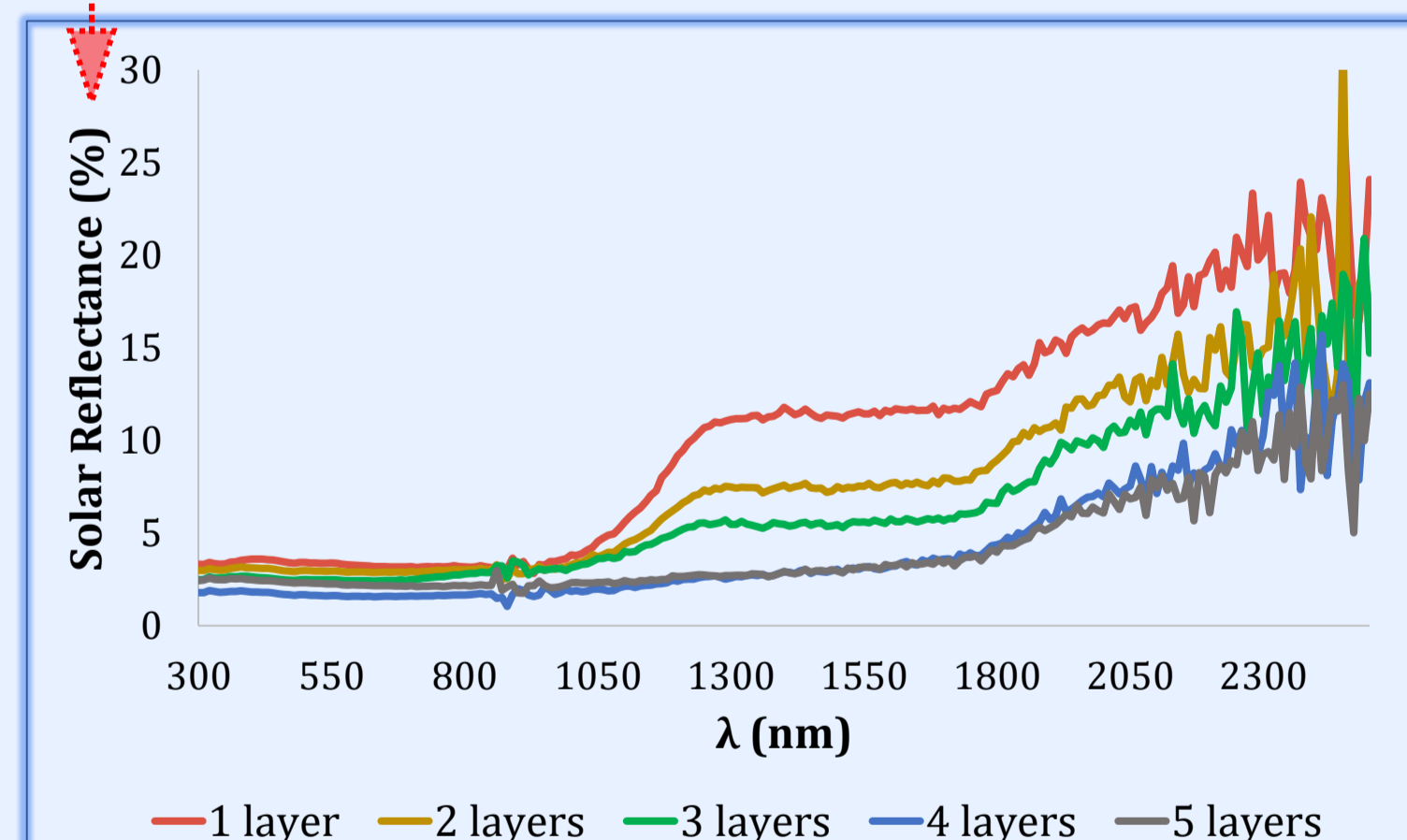


Fig. 4 Variation of the hemispherical reflectance spectra as a function of the number of spinel layers (Sol A) applied.

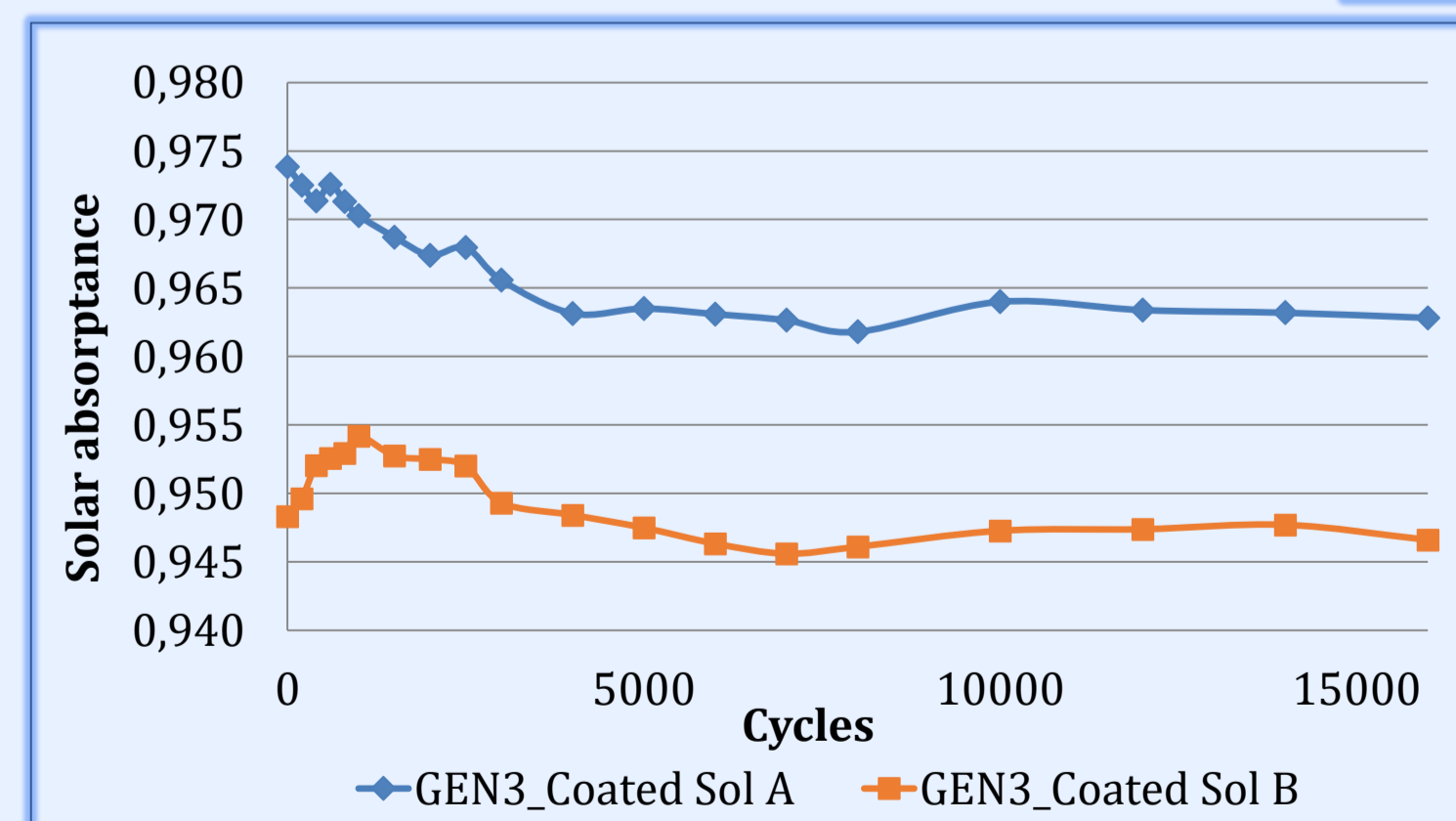


Fig. 5 Variation of the α_s value as the Taber abrasion cycles accumulate. Comparison of the behaviour of GEN3 particles coated with 5 layers of Sol A and Sol B.

Conclusions

The composition of both solid particles and spinel solution, the deposition of consecutive spinel-layers on solid particles and the methodology followed for their curing process showed a direct influence on the final α_s value and the abrasion resistance.

The porous spinel solution (SiO₂/spinel coating) improved the optical properties (α_s 0,979) and abrasion resistance (α_s 0,963 after 16000 accumulated cycles) of coated GEN3 particles. Four spinel layers of Sol A sintered each one at 1000 °C for 2 hours was determined as the optimal condition.