ALTERNATIVE ENERGY RESEARCH

ADVANCED OPTICAL MATERIALS
TO IMPROVE SOLAR ABSORPTION

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NOW MORE THAN EVER THERE IS A NEED TO TURN TO RENEWABLE, COST EFFECTIVE AND SUSTAINABLE ENERGY RESOURCES. IN RESPONSE, CSIR RESEARCHERS HAVE EMPLOYED THE USE OF PHOTONIC MATERIALS.

IN RURAL AFRICA, in particular, the demand for domestic energy is very high and is exacerbated by inadequate grid electricity infrastructure. This state of affairs has culminated in massive deforestation and desertification of some parts of Africa.

One technology solution is to harness the energy from the sun through solar absorbers. This has applications in domestic heating – such as heating water (solar geysers) and cooking.

Early solar energy technologies were not readily accepted in Africa because of high initial investment cost and low efficiency, particularly so for the not so rich rural populace. Presently, there is a re-look into the solar energy technologies with emphasis on cost effectiveness and sustainability.

One of the key factors in solar energy is the material used to absorb sunlight. The requirements of selective solar absorber materials used for low to moderate temperature applications such as domestic water heating collectors are high absorption in the solar wavelength range and an accompanying low thermal emittance in the near-infrared (NIR) and far-infrared (FIR) wavelength ranges.

The idea is simply that the material be such that it absorbs as much of the solar energy as possible, thereby getting very hot. Once it gets hot, it would tend to re-emit, following a grey or black-body spectrum. An ideal solar absorber would not re-emit any radiation, thus maximising transfer of energy by other means, such as heating by conduction (e.g. heating water in a rural village).

These requirements translate to a material that has low reflectance of less than 10% in the wavelength range from 300 nm to 2500 nm and a high reflectance of greater than 90% for wavelengths greater than 2500 nm. Today, no intrinsic material is capable of this selectivity.

ENTER THE PHOTONIC SPECIALISTS

CSIR researchers specialising in advanced photonic materials have succeeded in tailoring the optical and structural properties of materials to achieve the desired wavelength selectivity. Our novel selective solar absorber comprises carbon nano-particles embedded in a NiO (nickel oxide) matrix on an aluminium substrate. It shows enhanced solar radiation absorbance and low thermal emittance properties: laboratory tests show that it is approximately 30% more efficient than the best alternative on the market.

Furthermore, the sol-gel recipe that is used to manufacture the composite material has additional advantages of being environmentally friendly and has a low production cost. Control of the spectral selectivity in the coating is achieved by adjusting various parameters of the coatings, such as composition, thickness, porosity surface morphology and nanostructure, among others.

This technology is set to impact the lives of the poorest people in South Africa by providing them with a reliable energy source for domestic heating applications. For example, boiling water without the need for electricity or making a fire would have a huge impact on a rural household's safety and health and would generally result in a better quality of life for such communities.

A consortium of local universities, the private sector and NGOs, led by the CSIR's laser experts, has started a three year implementation programme to see that this laboratory research is realised in local communities for cleaner, safer energy.

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"Lab results show that CSIR laser researchers have developed a novel selective solar absorber that is about 30% more efficient than the best alternative on the market."