E2-17:Natural rubber sheet as the solar collector in a direct solar dryer

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Solar dryers are units designed to transfer solar radiation into heat. Of all the types of solar dryers available today, the direct solar dryer is the simplest one and economical for local use. It consists mainly of a chamber covered with a flat-plate which absorbs and transfers the solar radiation into heat inside the chamber. Hence the solar radiation transfer efficiency of a dryer, soleiy depends upon the characteristics of the flat-plate material.

Inorganic glass sheet has been found to be the most suitable material for this application. However, due to its fragile nature, the use of the material is limited.

Instead of inorganic glass, thermoset polyester fibre glass has been employed for this purpose, but the material is uneconomical for local use, because of its high cost.

The objective of this work was to identify an appropriate cheap local material as an absorber of solar radiation similar to inorganic and polyester fibre glasses.

Since natural rubber is a tough flexible polymeric material produced abundantly in this country, attempts have been made to utilise the rubber as the solar radiation absorber in a direct solar dryer.

Experimentally, as the raw rubber alone, is weak for this application, the rubber was incorporated with various compounding ingredients as given in the formulations:

Formulation I		**Formulation II**	
Ingredients	Pwt	*Ingredients*	Pwt
Natural rubber (RSS)	100	Natural rubber(RSS)	100
Zinc oxide	5	Zinc oxide	30
Stearic acid	2	Stearic acid	2
Sulphur	0.5	Sulphur	0.5
TMTD	3	TMTD	3
Carbon black (HAF)[1]	60	Carbon black(HAF)	60
Petroleum oil	5	Petroleum oil	5
Antioxidant (IPPD)[2]	1	Antioxidant (IPPD)	1
Antiozonant (Santoflex AW)[3]	1	Antiozonant (Santoflex AW)	1

[1]High abrasive furnace black [2]Isopropyl paraphenylene diamine
[3]6-ethoxy-1,2-dihydro-2,2,4-trimethyl quinoline

Carbon black in formulation I and formulation II, and Zinc oxide in formulation II have been loaded into the rubber to maximum level, specially to absorb solar radiation, to a great extent. Efficient vulcanising system has been chosen to cross-link the rubber molecules with strong bonds.

The mixes thus prepared, subsequently vulcanised in the form of 2 mm thick sheets of dimensions 1/2 x 1/2 m, by compression moulding technique. Each rubber sheet has then been utilised as the flat-surface cover of a laboratory model direct solar dryer and assessed for its solar radiation transfer efficiency.

For the assessment test samples of green beans were placed inside the chambers of the dryer units and the cover sheets' surfaces have been directed from time to time to face the sun, from 1000 to 4 1600 h for 5 consecutive days.

The following determinations were made in the test

(i) Average temperature inside the chamber of each dryer unit from 1000 to 1600 h per day.

(ii) Loss in weight of samples of green beans in each dryer unit after 5 consecutive days of drying.

For comparative studies, the same assessment tests were carried out in parallel with inorganic glass sheet and polyester glass sheet each of same thickness (2mm).

As the natural rubber products are generally susceptible to oxidative degradation reactions due to atmospheric oxygen and ozone in their service life, each vulcanised rubber produced was tested for assessing its durability, according to accelerated ageing air-oven method (ISO 188).

Test results are given in *Table 1 & 2*

Table 1 Assessment of solar energy transfer efficiency

Material used as cover in the solar dryer (^{O}C)	*Average temperature reached inside the Chamber of the dryer after 5 days (%)*	*Loss in weight of the sample kept inside the dryer*
a. Vulcanised natural rubber sheet containing 60 phr, carbon black (HAF)	44	75.0
b. Vulcanised natural rubber sheet containing, 60 phr, Carbon black (HAF) and 30 phr, Zinc oxide	51	82.0
c. Inorganic glass sheet	55	86.0
d. Polyester Fibre glass sheet	52	82.5

Table 2 Assessment of the durability of natural rubber vulcanisate, by accelerated ageing air-oven method

	Properties	*Vulcanised natural rubber containing 60 phr carbon black (HAF)*	*Vulcanised natural rubber containing 60 phr carbon black (HAF) and 30 phr zinc oxide*
(a)	Tensile strength (MN/m^2) original	26	27
	after 4 days at 100°C	21	23.5
(b)	Elongation at break (%) original	540	500
	after 4 days at 100°C	440	465

The test results for assessing the solar radiation absorption and transfer efficiency of the materials reveal that in a direct dryer.

(i) the efficiency of solar radiation transfer of natural rubber vulcanisate containing 60 phr, carbon black (HAF) and 30 phr, Zinc oxide is almost the same the as that of the polyester fibre glass.

(ii) natural rubber vulcanisate containing 60 phr, carbon black filler alone, does not function effectively as the solar absorber like the material inorganic glass or polyester fibre glass.

(iii) inorganic glass is the most effective material to be used as the solar absorber.

Zinc oxide is a good solar radiation absorber and heat conducting filler, it could contribute an additonal effect to the solar radiation sbsorption and transfer of the black vulcanisate.

The accelerated ageing test of rubber vulcanisates indicate that the retention of properties offered by both vulcanisates in the test is good. the reason is, because each vulcanisate has been produced with the same efficient vulcanising system, which confers the vulcanisates predominintly with strong monosulphidic cross-links. Future, the slightly better age resistance of 30 phr, zinc oxide incorporated black vulcanisate could be attributed to the high heat resistant character of the mineral filler.