# NANO TECHNOLOGY IN HEALTH AND HYGEINE FOOD PROCESSING AND HEAT TRANSFER OF CARBON-NANOFLUIDS

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## ABSTRACT:

Nanotechnology is a newly emerging novel food packaging technique,which can be increase the shelf life of food, minimize the spoilage, ensure the food safety, repair the tears in packaging, reduce the problem of food shortage, and finally improve the health of the people. It is hoped that nanotechnology has a great potential in food industries as it may be used to manufacture about 25% of all food packaging in near future. Emphasis is given to assess the safety of ingredients in nanoparticles before their use in food products including packaging. The effects of physical parameters on flow and heat transfer are analyzed with aid of graphs. The wall temperature gradient and skin friction quantities are numerically calculated and tabulated. Our results are in good agreement with earlier studies for some limitations cases.

**KEYWORDS:** Food products, Food safety, Human health, Nanoparticles, Nanotechnology, Packaging, Product.

## INTRODUCTION:

Nanotechnology is the science of very small material that has a big impact in food industry including packaging. Nanoparticals are mixed with polymer chain to improve the gas barrier properties, as well as temperature, humidity resistance of packaging.

Nanotechnology is a newly emerging technique, which involves the characterization, fabrication, and manipulation of structures, devices or materials that have at least one dimension having 1-

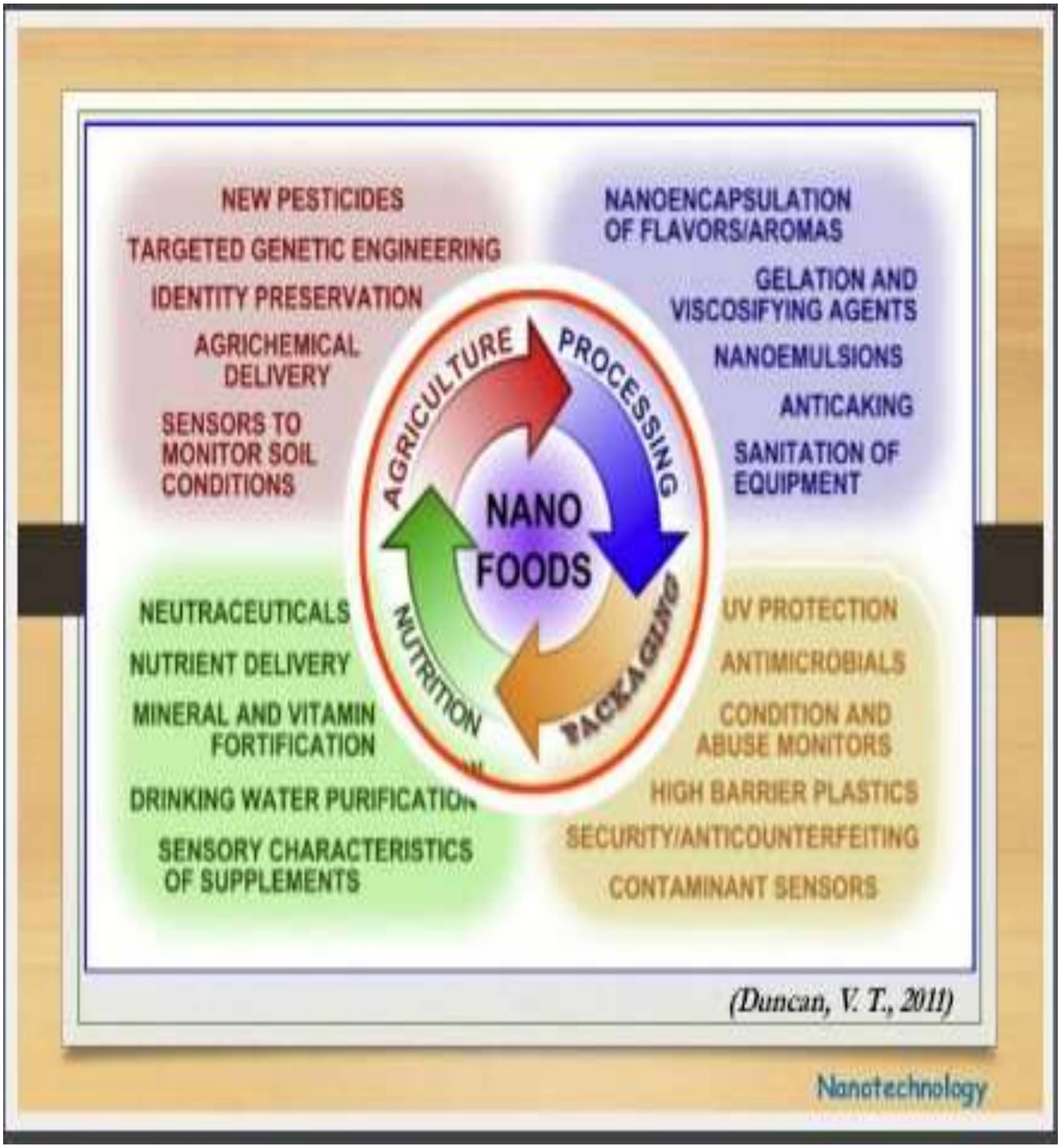
100 nm in length. This technology deals with nanomaterials and nanosystems commonaly smaller than 100 nanometers. Nanomaterials are defined as materials with any external dimension on the nanoscale, and are clustered into three classes, namely nanoparticles, nanofibers and nanoplates. Presently, over 400 companies in the world are developing nanotechnology for its application in food and food packaging it is estimated that over 400,000 scientist are working in the field of nanotechnology. Nanotechnologies are projected to impact use of nanomaterials at least US Dollar 3 trillion by the year 2020 Wesly et al. An active packaging can be designed to stop microbial growth once the package is opened by the consumer and rewrapped with an active film portion of the package. Nanotechnology application in food industries can be utilized to detect bacteria in packaging, or produce stronger flavor, color quality, and safety for increasing the barrier properties. Precautions are needed to apply nanotechnology in food as very little knowledge is available on its impact on environmental and human health. This communication aims to present the latest development in the field of nanotechnologies for food packaging application.

**Nano Science and Nanotechnology:**

“ Nanoscience is a study of phenomena and manipulation of materials at atomic, molecular, and micromalecular scales, here properties differs significantly from those at a large scale.”

“ Nanotechnology involves the characterization, fabrication and/or manipulation of structures devices or materials that have at least one dimension is approximately 1-100 nm in length.”

## MECHANISMS OF NANOTECHNOLOGY IN FOOD SCIENCE AND TECHNOLOGY



AGRICULTURE:

- Nanocapsules for delivery of pesticides, fertilizer and other agrichemicals more efficiently
- Nanosenser for monitoring soil conditions and crop growth.
- Nanoparticles to deliver DNA to plants (targeted genetic engineering).

PROCESSING:

- Nanocapsules to improve bioavailability of neutraceuticals in standard ingredients such as cooking oils.
- Nanotubes abd nanoparticles as gelation and viscosifying agents.
- Nanoemulsions and particles for better availability and dispersion of nutrients.

PACKAGING:

- Antibodies attached to fluorescent nanoparticles to detect chemicals foodborne pathogens
- Biodegradable nanosensors for temperature, moisture and time monitoring
- Nanoclays and nanofilms as barrier materials to prevent spotlage and prevent oxygen absorption

NUTRITIONS:

- Nanosize powders to increase absorption of nutrients
- Cellulose nanocrystal composite as drug carrier
- Vitamin sprays dispersing active molecules into nanodroplets for belter absorption.

## Theoretical models for effective thermal conductivity

Several theoretical models, capable of predicting the effective thermal conductivity enhancement of CNT suspensions, are available in open literature. All of these models are based on Fourier's law of heat conduction. Maxwell (1904) proposed an explicit relation for the effective thermal conductivity in terms of the thermal conductivity ratio, $u = \frac{xy}{x+y} showthat x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = u$ and the volume fraction $\varphi$

$$\frac{k_{nf}}{k_f} = 1 + \frac{3(\alpha-1)\varphi}{(\alpha+2)+(\alpha-1)\varphi} \quad (1)$$

Considering higher orders of volume fraction, Jeffery (1973) and Davis (1986) proposed the following theoretical models

$$\frac{k_{nf}}{k_f} = 1 + 3\lambda\varphi + \left(3\lambda^2 + \frac{3\lambda^2}{4} + \frac{9\lambda^2(\alpha+2)}{16(2\alpha+3)} + \cdots \ldots\ldots\right)\varphi^2 \quad (2)$$

$$\frac{k_{nf}}{k_f} = 1 + \frac{3(\alpha - 1)\varphi}{(\alpha + 2) + (\alpha - 1)\varphi}\{\varphi + \varphi(\alpha)\varphi^2 + o(\varphi^3)\} \quad (3)$$

respectively, where $\lambda = \frac{(\alpha - 1)}{(\alpha + 2)}$ The higher order terms represent pair interactions of randomly dispersed spheres. For low-volume fractions, the above three models result nearly identical predictions of the effective thermal conductivity. Furthermore, these models do not compensate for the shape factor of the particles. Hamilton and Crosser (1962) developed a theoretical model which accounts for the shape factor of the particles

$$\frac{k_{nf}}{k_f}\alpha + (n - 1) - (n - 1)\varphi = \frac{\square}{\alpha(\square + (n - 1) + (1 - \alpha)\varphi)} \quad (4)$$

where n is the shape factor of a particle given by $n = {}^{3}/_{\varphi^{(1)}}$ where φ=1 for spheres and 0.5 for cylinders and x ranges from 1 to 2. When φ=1; the Hamilton and Crosser (HC) model reduces to Maxwell model. Choi et al. (2001) shows that for cylindrical shape particles the HC model (n = 6) significantly underestimated the experimental data by showing a very minor increase of about 10 % for 1.0 vol% nanotubes in oil in comparison to the 160 % experimental enhancement in the thermal conductivity.

Xue (2005) noticed that the existing models are only valid for spherical or rotational elliptical particles with small axial ratio. Furthermore, these models do not account for the effect of the space distribution of the CNTs on thermal conductivity. Xue (2005) proposed a theoretical model based on Maxwell theory considering rotational elliptical nanotubes with very large axial ratio and compensating the effects of the space distribution on CNTs

$$\frac{k_{nf}}{k_f} = \frac{1 - \varphi + 2\varphi\frac{k_{CNT}}{k_{CNT} - k_f}\ln\frac{k_{CNT} + k_f}{2k_f}}{1 - \varphi + 2\varphi\frac{k_f}{k_{CNT} - k_f}\ln\frac{k_{CNT} + k_f}{2k_f}} \quad (5)$$

In this study, we have employed Xue (2005) model to determine thermal conductivity and the dimensionless heat transfer rates of nanofluids. In the next section, we will develop the mathematical model to investigate the skin friction and the dimensionless heat transfer rates of different nanofluids. In ''Numerical method'' we will discuss the numerical approach to solve the proposed model. Finally, we will present the physical interpretation and significance of our results.

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## Mathematical model

We consider the two-dimensional flow over a stretching sheet with heat transfer in water/oil-based nanofluids containing single and multi-wall CNTs. The flow is assumed to be laminar, steady, and incompressible. The base fluids and the CNTs are assumed to be in thermal equilibrium. The ambient temperature is assumed to be constant. Using order of magnitude analysis, the standard boundary layer equations for this problem can be written as follows:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \qquad (6)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\nu_{nf}\frac{\partial^2 u}{\partial y^2} \qquad (7)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha_{nf}\frac{\partial^2 T}{\partial y^2} \qquad (8)$$

where u and v are the velocity components along the x- and y-axes, T is the temperature, $\nu_{nf}$ and $\alpha_{nf}$ are the effective kinematic viscosity and thermal diffusivity of nanofluids, respectively. The effective properties of nanofluids may be expressed in terms of the properties of base fluid and carbon nanotubes, and the solid volume fraction of CNTs in the base fluids as follows

$$\left.\begin{aligned}\rho_{nf}&=(1-\varphi)\rho_s+\varphi\rho_{CNT}\\(\rho c_p)_{nf}&=(1-\varphi)(\rho c_p)_f+\varphi(\rho c_p)_{CNT}\\\nu_{nf}&=\frac{\mu_{nf}}{\rho_{nf}},\alpha_{nf}=\frac{k_{nf}}{(\rho c_p)_{nf}}\end{aligned}\right\} \qquad (9)$$

where $k_{nf}$ is the thermal conductivity of the nanofluid (see Eq.5), $(\rho c_p)_{nf}$ is the heat capacity of nanofluid and ϕ is the solid volume fraction of nanofluid. The hydrodynamic and thermal boundary conditions for the problem can be written

 

$$\left.\begin{array}{l} u = cx v = 0 T = T_w at y = 0 \\ u \to 0 v \to 0 T \to T_\infty y \to \infty \end{array}\right\} \quad (10)$$

where c is the stretching parameter and $U_\infty$ is the free stream velocity. We look for a similarity solution of Eqs. (6), (7), (8), (9) and (10) of the following form

$$\eta = \sqrt{\frac{c}{v_f}} y, u = cxf'(\eta) v = -\sqrt{cv_f} f(\eta) \theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty} \quad (11)$$

where η is the similarity variable and $Re_x = U_\infty x / v_f$ is the local Reynolds number based on the free stream velocity and the kinematic viscosity of the base fluid. The stream function ψ is defined as $u = \partial\psi / \partial y$ and $v = -\partial\psi / \partial x$ : Employing the similarity variables (11), Eqs. (6), (7) and (8) reduce to the following nonlinear system of ordinary differential equations:

$$f''' + (1-\varphi)^{2.5}\left[\left(1-\varphi+\rho_{CNT}/\rho_f\right)\left\{ff' - f'^2\right\}\right] = 0 \quad (12)$$

$$\left(\frac{k_{nf}}{k_f}\right)\theta'' + p_r\left(1-\varphi+\varphi\frac{(\rho c_p)_{CNT}}{(\rho c_p)_f}\right)(f\theta') = 0 \quad (13)$$

subject to the boundary condition (10) which become

$$\begin{array}{l} f(0) = 0, f'(0) = 1 at f'(\infty) = 0 \\ \theta(0) = 1 \theta'(0) = 0 as \theta(\infty) \to 0 \end{array} \quad (14)$$

Here, primes denote differentiation with respect to η , $P_r = \frac{(\mu c_p)_f}{k_f}$ is the Prandtl number of the base fluid.

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## ➢ Numerical technique

The system of coupled nonlinear differential Eqns. (12) and (13) along with the boundary conditions Eqn. (14) are solved numerically using fourth order Runge-Kutta Fehlberg method with shooting technique for different values of governing parameters including Prandtl number $P_r$ , and CNT volume fraction φ.The boundary value problem is first transformed into an initial value problem (IVP) . Then thr IVP is solved by a systematic guessing for $f''(0)$ and $\theta'(0)$ until the boundary conditions have been at ∞., asymptotically decay to zero is to obtained numerical solution .The step size and the convergence criteria were taken as $\Delta\eta$ =0.001and $10^{-6}$ respectively.

## ➢ Results

The flow and heat transfer of single & multi wall CNTs fluids have been investigated. The governing partial differentials equations and the corresponding boundry conditions are converted into set of non linear ordinary differential equations and these equations are solved numerically.

## Conclusion:

The present study investigates the flow and heat transferor carbon nano fluids along the stretching sheets with the boundary conditions. It is concluded that

1. The effect of solid volume fraction reduce velocity for both the case SWCNT and MWCNT and the boundary layer thickness also decreases.

2. The heat transfer rate increases with the increase of nano particle fraction for both cases SWCNT MWCNT.

3. The heat transfer profile decreases with the increase of Prandtl number for fix value of solid volume fraction for both cases SWCNT and MWCNT .

4. It is observed that the influence of Pr for temperature profile and nano particle fraction, as Pr has decreasing behavior for θ (η) .

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