

ABSTRAK

Kekurangan air tawar global mendorong pengembangan teknologi desalinasi inovatif, di mana desalinasi berbasis energi surya muncul sebagai alternatif berkelanjutan untuk menggantikan metode konvensional berbahan bakar fosil. Namun, teknologi ini masih menghadapi tantangan fundamental terkait manajemen panas dan akumulasi garam (*salt fouling*). Penelitian ini bertujuan untuk memanufaktur dan mengevaluasi kinerja alat desalinasi air yang mengintegrasikan teknologi *Solar Steam Generation* (SSG) menggunakan *fabric* desalinasi inovatif. *Fabric* ini dirancang dengan mengkombinasikan serat karbon sebagai lapisan penyerap fototermal dan serat selulosa regenerasi (Tencel) sebagai jalur pasokan air hidrofilik. Pendekatan manufaktur dilakukan melalui teknik penenunan (*weaving*) mekanis terkontrol dengan memvariasikan struktur anyaman, *Pattern 1*, *Pattern 2*, dan *Pattern 3*. Desain *Pattern 3 (4:1 twill)* terbukti memberikan efisiensi absorpsi optik yang optimal.

Hasil karakterisasi dan evaluasi material menunjukkan bahwa kombinasi ini mengelola distribusi fluida melalui aksi kapiler secara mandiri dan berfungsi sebagai isolator termal yang melokalisasi panas pada antarmuka evaporasi. Pengujian eksperimental mendemonstrasikan bahwa arsitektur tekstil *Pattern 3* mampu mencapai laju penguapan tertinggi sebesar 4,95 kg/m²h di bawah iradiasi *solar simulator* sebesar 1 *sun*. Pengujian alat desalinasi air secara *indoor* menggunakan solar simulator didapatkan nilai rata-rata laju evaporasi total sebesar 1,058 kg/m²h. sedangkan pada pengujian sistem secara *outdoor*, nilai laju evaporasi rata-rata harian sebesar 1,041 kg/m²h. Sistem desalinasi air dengan *fabric* kombinasi serat karbon dan tencel mampu mencegah penyumbatan pori (*pore blockage*) dan memaksimalkan pemisahan air tawar. Hasil penelitian juga mengonfirmasi bahwa arsitektur tekstil secara mandiri dapat mengatur perpindahan panas dan massa (*heat and mass transfer*) secara efektif tanpa memerlukan pelapis tambahan maupun modifikasi kimia sekunder. Kerja ilmiah ini menetapkan sebuah platform tekstil fototermal yang murah, berkinerja tinggi, dan dapat ditingkatkan skala produksinya dengan sifat-sifat fungsional yang dapat disesuaikan melalui variasi desain tenun.

Kata kunci: Desalinasi, Serat Karbon, Energi fototermal, Tencel, *Solar Steam Generation*

ABSTRACT

The global freshwater shortage drives the development of innovative desalination technologies, wherein solar-driven desalination has emerged as a sustainable alternative to conventional fossil-fuel-based methods. However, this technology still faces fundamental challenges regarding heat management and salt accumulation (salt fouling). This study aims to manufacture and evaluate the performance of a water desalination device that integrates Solar Steam Generation (SSG) technology using an innovative desalination fabric. This fabric is designed by combining carbon fiber as the photothermal absorbing layer and regenerated cellulose fiber (Tencel) as the hydrophilic water supply pathway. The manufacturing approach was conducted through controlled mechanical weaving techniques by varying the weave structures into Pattern 1, Pattern 2, and Pattern 3. The Pattern 3 (4:1 twill) design proved to provide optimal optical absorption efficiency.

Material characterization and evaluation results indicate that this combination autonomously manages fluid distribution through capillary action and functions as a thermal insulator that localizes heat at the evaporation interface. Experimental testing demonstrated that the Pattern 3 textile architecture was capable of achieving the highest evaporation rate of 4.95 kg/m²h under 1 sun irradiation from a solar simulator. Indoor testing of the water desalination device using a solar simulator yielded an average total evaporation rate of 1.058 kg/m²h, whereas outdoor system testing recorded an average daily evaporation rate of 1.041 kg/m²h. The water desalination system, utilizing the carbon fiber and Tencel combination fabric, successfully prevented pore blockage and maximized freshwater separation. The findings also confirm that the textile architecture can autonomously and effectively regulate heat and mass transfer without the need for additional coatings or secondary chemical modifications. This scientific work establishes a low-cost, high-performance, and scalable photothermal textile platform with functional properties that can be tailored through variations in weave design.

Key words: Desalination, Carbon Fiber, Photothermal Energy, Tencel, Solar Steam Generation